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STREET IMPROVEMENTS IN CHICAGO are being undertaken with some vigor under Mr. McGann, the Commissioner of Public Works. In order to facilitate the bicycle traffic it is proposed to lay strips of asphalt paving on the sides of some streets, and it is suggested that these should extend to the curb so as to facilitate street cleaning, as has been done in New York. The bicyclists, however, now want the entire width of the streets paved with asphalt, so that their progress may not be impeded by vehicles on the asphalt strips. As the street railway tracks in the business district of the city are so numerous as to seriously interfere with vehicle traffic, the commissioner has proposed to the railway companies to form a loop line on Fifth Ave., Washington St., Van Buren St. and Dearborn St., leaving the enclosed district (five blocks long and three blocks wide) free from tracks. The loop would have both cable and electric traction to accommodate all the lines reaching it, and its operation would be arranged so that West Side cars would go in one direction on the outer track, while North Side cars could go in the opposite direction on the other track. A part of the project is to remove car tracks from one or two of the bridges, leaving them free for road traffic, and it is thought that with a systematic arrangement of the traffic two bridges on the West Side and two on the North Side would (in addition to the tunnels) be sufficient for the street railway traffic. Now that asphalt paving has been laid on one cross-town street (Jackson St.), it is proposed to lay similar paving on another street farther north, either Monroe, Washington or Salle St.

THROWING WASTE PAPER INTO THE STREETS has been forbidden in Chicago as one step towards keeping the streets in a better condition, and the following card is now being distributed among householders and merchants:

You are hereby notified that the indiscriminate practice of throwing waste paper in the streets, alleys, public places or unincloscd grounds, must cease, under penalty as provided by section 2,179, paragraph 1,587 of the Municipal Code.

"No person shall throw, cast or put into, drop or leave in any street, alley, lane, public place, or any unincloscd grounds in the city of Chicago, any paper, straw, parings of fruit or vegetables, stone, glass, iron or any other metal, article or thing, except ashes on unpaved streets or alleys, under the penalty of not less than $5 nor more than $25 for the first offense, and for every subsequent offense, shall, in addition to such penalty, be liable to imprisonment for not less than one week nor more than three months in the house of correction."

And any person found violating the above ordinance will be arrested and prosecuted to the full extent of the law.

Burn the paper or put same in covered garbage box.

L. E. McGann, Commissioner of Public Works; Jos. Kipley, General Superintendent of Police; John Fitzsimmons, Superintendent of Street and Alley Cleaning.

THE POPULATION OF TOWNS OF OVER 1,000 INhabitants in the United States has been estimated by the health officials of each place, and the estimates have been sent to Dr. Wyman, of the Marine Hospital Service, in answer to a request for this information as a basis for the compilation of statistics of mortality. These estimates must, of course, be taken with some caution, but the comparison of the cities of greatest population is given as follows:

	1890.	1896.
New York	1,515,301	1,995,000
Chicago	1,099,850	1,619,226
Philadelphia	1,046,964	1,188,793
Brooklyn	806,343	1,100,100
St. Louis	451,770	570,000
Boston	448,477	516,305
Baltimore	434,439	506,378

PLANS FOR A 25,000,000-GALLON FILTERING plant for the water supply of Louisville, Ky., are to be made by Mr. Chas. Hermony, M. Am. Soc. C. E., Chief Engineer of the Louisville water-works, and Mr. Geo. W. Fuller chemist and bacteriologist of the works. The plans are to embody the best features and methods developed by the recent tests of mechanical filters at Louisville.

THE MOST SERIOUS RAILWAY ACCIDENT of the week, occurred Aug. 29 on the Chicago & Alton R. R., on the outskirts of Chicago, Ill, and was a derailment said to be due to spreading of the rails. The engine and baggage-car were completely wrecked, and the engineer and fireman were injured.

MORE RAILWAY MATERIAL FOR JAPAN is soon to be purchased. A set of specifications for material sufficient to build about 160 miles of track, have recently been received by Joseph U. Crawford, Philadelphia, Pa., consulting engineer for the Japanese government. These include some 16,000 tons of 60-lb. steel rails, and about 2,000 tons of fish plates, bolts, etc. Thirty locomotives are also included.

A SWITCH DERAILMENT ACCIDENT occurred at Riverdale, Chicago, on the Chicago Terminal Transfer R. R., Aug. 22. As an excursion train was returning from the Drainage Canal to Hammond, and approaching Riverdale station, the engineman discovered the facing-point switch about half thrown. He made an emergency application of the brakes and reversed the engine, but the train was derailed. The men in charge of the train immediately examined the switch and found the staple broken off and the lock gone, the switch being for a Y track and left locked. The lock could not be found, but Mr. E. R. Knowlton, Superintendent, informs us that next morning, when the engine was being picked up, he ordered a man to search for the lock and it was found in a field, about 100 ft. from the switch. The lock was badly battered and was attached to the broken staple from the switch. The Superintendent thinks this was evidently the work of brass thieves, who broke the staple, but after realizing what they had done, threw away the lock for fear of detection.

THE TRAFFIC ON THE LONDON METROPOLITAN and Metropolitan District railways for the first half of 1897 amounted to 69,260,675 passengers. At this rate the total traffic for 1897 would be 138,521,350. In 1896 the actual number of passengers carried was 131,131,305, as compared with 121,163,803 in 1886, and 76,388,417 in 1876. The Metropolitan railway is a little over 69 miles long, and the Metropolitan District operates about 14⅔ miles. The length of line worked by the engines of the first named company is 80 4-5 miles, and that of the second is about 36 miles. During the first half of 1897 the aggregate train mileage of the Metropolitan was 1,441,152 miles, and that of the Metropolitan District was 765,426 miles. The one company on July 1, 1897, owned 80 locomotives, 406 passenger cars and 242 freight trucks, and the other company owned 54 locomotives, 374 passenger cars and 35 freight cars. The capital expended by the Metropolitan Railway to July 1, 1897, was $61,323,765, while the Metropolitan District had expended to the same time $38,681,065. The net revenue from the first named line for the first half of 1897 was $1,174,260, and that of the Metropolitan District was $627,740.

AN OVERHEAD CABLE TRAMWAY, from Dyea to the Klondyke mines, is proposed by L. R. Radcliff, of St. Louis. The St. Louis "Republic" says that he is now preparing to ship his cables and machinery to Seattle and thence to the far north, with the intention of building his tramway in the next spring and have it in working order over the pass for the following winter. Meanwhile he also proposes warehouse stations along the proposed line to be worked by burros for the transport of miners' supplies.

TELEGRAPH COMMUNICATION with the Klondyke seems to be the next step in the rapid development of that region, and articles of incorporation have been filed in San Francisco by the Alaska Telegraph and Telephone Co. As outlined by the company, the project includes a line from Juneau to Dawson City along a well known trail. The interesting feature of the telegraph and telephone circuits rests in the conductors, both of which are enclosed in a cable, which will be run along the ground without poles or insulators. Stations will be placed about 50 miles apart for convenience in sending messages and inspecting the cable. From Dawson City branch lines will be run to City Circle and Forty Mile. There is considerable doubt as to the wisdom of such a venture from a financial standpoint, owing to the expense of construction and the few messages which can be expected even under favorable circumstances. However, it has its good features, not the least being the closer connection of Alaska with the United States. Unfortunately, even this advantage is doubtful where the cable and stations are so exposed and accessible for tampering.

THE LARGEST TELEPHONE CABLE CONTRACT ever given is reported from St. Louis as a result of the telephone wires being placed under ground in that city. The statement that the contract covers 650,000 ft. of cable containing fully 100,000,000 ft. of No. 19 B. & S. copper wire, 2,000,000 lbs. of lead casing and thousands of pounds of paper insulation can only be appreciated by comparisons. 650,000 ft. equals about 124 miles or about the distance from New York along the coast to Cape May, or the very end of New Jersey. The small wires, if spliced together, would reach nearly half round the earth, the total length being 18,900 miles. One thousand tons of lead would equal in weight a solid prism of cast iron 10 ft. square and 45 ft. high.

HIGH POTENTIAL TESTING TRANSFORMERS are being furnished by the General Electric Co. for testing circuits, switches or translating devices with an alternating current, using as high as 10,000 volts. The apparatus consists of a small transformer, of the well-known type H design, placed in a substantial mahogany casing, which is provided with handles and suitable binding posts for convenience in handling and operation. In construction the greatest care is used to properly insulate the parts, and each instrument is tested with a maximum strain of 35,000 volts between the primary and secondary windings. To regulate the potential an adjustable spark gap is provided, which has a micrometer adjustment. This is shunted across the terminals of the high tension winding and is enclosed in a small box with a glass window on top of the main case. This is arranged so that when lifted the circuit is broken and all danger obviated. A double primary is employed to admit of use upon either 52 or 104 volt circuits, and the transformer is also designed to run with either 60 or 125 cycle and give 10,000 volts at a normal current of .05 amperes.

THE "THREE-DAY" STEAMER TRIP TO EUROPE, via Newfoundland, is revived by Dr. Wilfrid Grenfell in an article on the resources of Newfoundland. The project has been started by the railway commenced between St. Johns, on the east coast, 550 miles westward to Port au Basque, only 90 miles from Sidney, the eastern terminus of the Intercolonial Railway in Nova Scotia. This railway is already developing rich lumber and mineral interests, and will be open in its whole length by June of next year. A steamer line is being established to transfer passengers and mails in six hours from Sidney to Port au Basque. It is now pointed out that with this line in operation a new route is opened from the United States to Europe—given proper and fast steamers at St. Johns. The trip would be made by the Maine Central to St. John, N. B., the Intercolonial to Sidney, N. S., by steamer 90 miles to Newfoundland, and by rail 550 miles across to St. John's; and from the latter point a fast steamer could cross to Cork in three days. But as some one once remarked, it is the first three days of a steamer passage that count; and to provide a perfectly acceptable line to the susceptible traveler, these first three days would have to be eliminated. In other words, there is no gain to the passenger in a three-days' trip, especially when this is coupled with a long and uncomfortable land trip to begin with.

A RAILWAY TO INDIA, from Alexandria to Agra and Bombay, is proposed by C. E. D. Black, in a paper read before the English Society of Arts. The line would be 2,400 miles long, from Port Said to Kurrachee, and would cross upper Arabia to Basra, at the head of the Persian Gulf; and skirt the north shore of the Gulf and the Arabian Sea to Kurrachee, on the border of India. Mr. Black advocates the route for political purposes mainly, though he thinks the revenue would be sufficient to pay a fair interest on its estimated cost of $75,000,000.

A BICYCLE RUN OF 1,900 MILES has been completed by the 25th U. S. Infantry Bicycle Corps. Two officers and 20 soldiers left Fort Missoula, Montana, on June 14, bound for St. Louis, over 2,000 miles away. The first twelve days were rainy and disagreeable, but good time was made. In Nebraska, sand 8 to 10 ins. deep on the road compelled the corps to take the railway for about 200 miles. The trip was made in 40 days, 35 of which were actually spent on the road; and for the actual distance traveled on bicycles, the average run per day was 52.6 miles; and for a time the average was over 60 miles per day. Though the heat for the last three days was severe, the men stood the trip remarkably well, one man only being returned to Fort Missoula owing to his inability to keep up with the rest.

JAPANESE CHEAP LABOR is seemingly passing away before the advent of modern civilization. Japan is now importing cheap laborers from Corea to work her coal mines, owing to the rise in local demands. In five years the wages of carpenters have increased from 33 to 80 cts. per day, silver; and in the same time the cost of living has nearly doubled. Rice, which in 1890 cost $4.90 per "koku," is now selling at from $8.90 to $9.10, silver.

IN SENDING CATALOGUES to Japan the approximate prices of all goods must, according to London "Engineering" invariably be given to make them of any value. The government officials make up estimates for work and must have prices to know how much of an appropriation to ask for, and unless prices are specified, the time required to communicate often turns contracts into the hands of those understanding the existing conditions.

THE SYSTEM OF PROTECTION OF CORNING, N. Y., FROM FLOODS IN THE CHEMUNG RIVER.

The city of Corning, N. Y., is situated on the banks of the Chemung River, about 40 miles above its junction with the Susquehanna. Part of the city is on the south and part on the north bank of the river. The main portion, on the south side, extends from the river across the flats to and up the hills which bound the valley, and on the north side the level country is partly covered by the Fifth Ward of the city. Two miles above the city the Tioga River, from the mountains of Pennsylvania on the south, and the Conhocton, from the north and west, come together to form the Chemung River; 4 miles above this junction the Canisteo empties into the Tioga. All of these streams, including the Chemung, fall, in the neighborhood of Corning, from 4 to 6 ft. to the mile. The Conhocton and the Canisteo are, throughout, of smaller slope than the Tioga, which near its headwaters in the mountains has a fall as great as 80 ft. to the mile, and most of its smaller tributaries are of great slope, and at times become mountain torrents. These conditions fix the character of the Chemung, and in times of great rainfall great floods result. The floods, which occur once or twice a year, were generally large enough to overflow part of the flats on the north side of the city and some of the land on the south side. The greatest known flood occurred in June, 1889, and caused serious damage to property. It was in consequence determined to protect the city from such damage in the future, and an act of the Legislature, passed in 1892, created a Board of River Commissioners and gave authority to issue bonds for this purpose. An investigation and report in August, 1892, by Prof. P. C. Ricketts, M. Am. Soc. C. E., showed the amount allowed by this act to be insufficient to do the required work. The Legislature afterwards permitted the city to issue bonds to the amount of $150,000; the specifications were drawn in March, 1896, and the work was commenced in June of the same year. It is now nearly completed.

Earthen dikes are used to confine the river and other streams, and the map, Fig. 1, shows these dikes in heavy lines. The river flows eastward through the town; on the west the city is protected from upstream floods by the Cutler Creek dike, the Erie Railway embankment and the short dike extending from the south end of the Erie bridge to the Fall Brook Railway tracks, which extend along the hillside at this point so that the water is cut off to the south. It was necessary to raise the Fall Brook tracks for a distance of 2,200 ft., the maximum fill of 5 ft. occurring opposite the Erie bridge. All flood water must therefore pass between the abutments of this bridge.

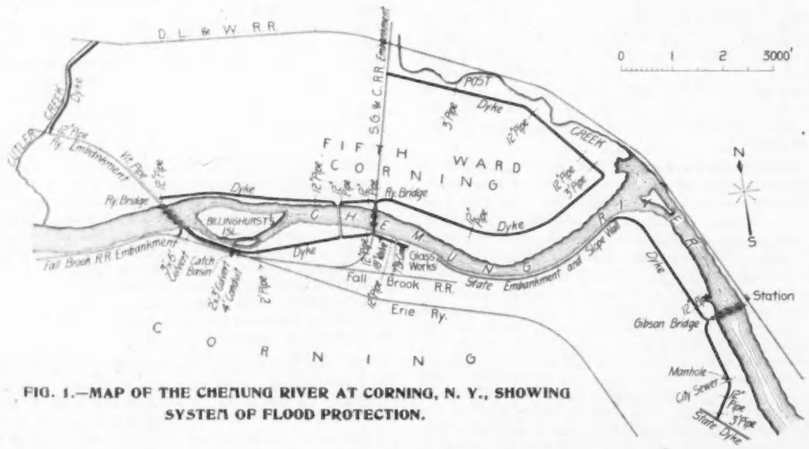

FIG. 1.—MAP OF THE CHEMUNG RIVER AT CORNING, N. Y., SHOWING SYSTEM OF FLOOD PROTECTION.

The limiting cross section is that under the Syracuse, Geneva & Corning Ry. bridge, which was originally 9,600 sq. ft., but which has been increased by excavation under the north span to 10,500 sq. ft. A span 140 ft. in clear length was added on the south end of the Bridge Street highway bridge, thus increasing the clear opening under the stringers from 8,600 to 10,600 sq. ft. Economic considerations prohibited an extension of the S., G. & C. Ry. bridge and the straightening of the channel at this point. For the same reason Billinghurst's Island was not removed and the dike between the south ends of the Erie and Bridge Street bridges straightened. The railroad embankment along a part of this portion between these two bridges was utilized as a backing for the dike, the top of which was only a few feet above the grade of the tracks, and an inexpensive construction was thus obtained. From the S., G. & C. Ry. embankment, on the south side, the dike was extended to the Glass Works. These works are above flood level, and the State had already constructed an embankment, faced with a stone slope wall, extending from the end of the works easterly for a distance of 4,000 ft. to the beginning of the curve shown on the map. Therefore the dike was begun again at this point, extending thence to the Gibson bridge and beyond it to the State dike below the bridge. A span of 140 ft. in the clear was added to the west end of this bridge.

On the north side of the river the main dike extends from the Erie Railway embankment eastward to the mouth of Post Creek, and thence westward along the creek to the S., G. & C. Ry. embankment, thus enclosing the Fifth Ward of the city. The tracks of the Delaware, Lackawanna & Western R. R., on a high level, also protect the city on the north.

The total length of the dikes is about 25,800 ft., or about 4.9 miles, and they vary in height from 4 to 19 ft. The total net amount of earth moved,

Fig. 2.—Base of Dike Cleared of Sod and Ploughed Ready for Embankment.

that is, the amount measured from the cross sections required after shrinkage had taken place, was about 330,000 cu. yds., and the price paid per yard was 13.9 cts. This price covered clearing, removal of vegetable material and soft spots and provision for shrinkage. Most of this work was done with drag and wheel scrapers, though for a considerable amount a "Western Elevating Grader" and wagons were used. The following extracts from the specifications explain the method of construction:

The river dikes will generally be 8 ft. wide on top, with a slope of three to one (three horizontal to one vertical) on the river side, and a slope of two to one on the land side. These widths and slopes, however, are not absolute, and they may in any place, and in some places will, be changed at the discretion of the engineer.

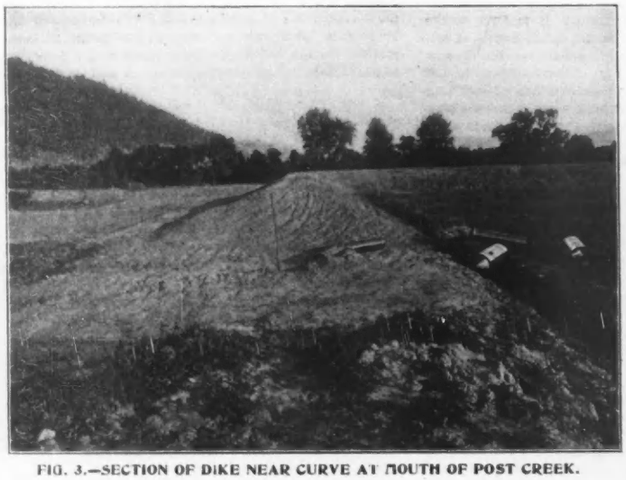

FIG. 3.—SECTION OF DIKE NEAR CURVE AT MOUTH OF POST CREEK.

FIG. 4.—LOW GRAVEL DIKE AT CUTLER CREEK, SHOWING SOD COVERING IN FOREGROUND.

All of these dikes will be made of clay and gravel taken from between the toes on the two sides of the river or between the toe and Post Creek. If at any place gravel only can be obtained by the shortest haul the contractor must elsewhere obtain suitable material to mix with it and reasonably compact it; the amount of such material to be determined by the engineer. Generally this material may be taken so that scrapers may be used and the haul be the shortest, but deep hollows will not be permitted to be scooped out near the toes, and if humps or elevations occur inside the toe line within a reasonable scraper distance the material in them will be preferably used. Berms not less than 10 ft. wide will generally be left along the toes and the hollows scraped will not be greater than 4 ft. in depth. A three to one slope will generally be left in the old ground outside the berms. In cases where the toe will coincide with the present river bank, material must be taken elsewhere between the dikes.

No vegetable material will be used in the construction

Fig. 5.—Mouth of Brick Conduit, Showing Stone Invert at End.

of the dikes, except in the covering, as hereinafter described. All vegetable material, including grass, bushes, roots, etc., will be scraped or otherwise cleared from the base of the dikes between the toes of the slopes until clean material, such as earth and clay, earth and gravel, clay and gravel, etc., is reached. All trees and stumps, including their roots, will be removed, the stumps preferably by blasting. If soft spots occur, the soft material will be scraped out or otherwise removed until a firm bottom is secured. After the ground has been cleared of vegetable material it will be well broken with a plow in order to obtain a good bond with the new material.

The material used in the construction of the dikes will be placed in layers. The first few layers will be thicker near the toes than in the middle; and the upper surface, as the filling proceeds, will be kept hollow towards the middle, about one foot lower in the middle than at the edges. Wheel scrapers will preferably be used. If wheel scrapers be used the layers may be 12 ins. thick, and need not be tamped except by the scrapers and horses. If wheelbarrows or carts or wagons be used the layers will not be more than 9 ins. thick, and the material will be tamped by rammers or rollers, or by riding horses over it. Material will not be dumped in piles without being spread and compacted as above described. To provide for shrinkage the dikes will be 10% higher than the elevations finally required. That is, at a point where the dike is 10 ft. high it will be made 11 ft. high at the top, and the slopes will be left higher by the same percentage of their height at any point. No work will be done on the dikes before the frost is out of the ground in the spring, or after the first frost in the autumn.

The dikes will finally be levelled up on top. They will be covered on top and on both sides by 6 ins. of earth suitable for the growth of grass. This earth will not be placed on top after the rest of the dike is finished, but will be incorporated with the other material as the building proceeds. The material scraped from the bottom, if suitable, may be used for this covering. Grass seed, consisting of equal parts of Kentucky blue grass, hard fescue, sheep's fescue, red fescue and various-leaved fescue will be sowed on top and over both slopes from toe to toe about the first of April. Five bushels, of 14 lbs. each, will be used for each acre of surface sowed. It will be raked or harrowed in.

The tender of the contractor will include a price per cubic yard for the material in the dikes measured as described below. The material will be measured from the surface made by removing vegetable material and soft spots as above described. No excavation of any kind will be paid for. There will be no price made for excavation. The time of final measurement will be at the discretion of the engineer. The price per cubic yard will cover all scraping, removal of trees, etc., under the dikes, as above described, removal of soft spots and grass seed sowed in place. It will cover everything necessary to complete the dikes as above described in every respect.

The amount of material added for shrinkage will not be paid for. That is, at any point the cross section paid for will extend from the cleared base to the elevation finally required, as shown on the map and called for by the engineer, with the slopes required by the engineer for such height of dike, and all excess of material added to provide for shrinkage must be included in the price tendered per cubic yard for the cross section above described.

These clauses were generally strictly enforced. One exception made was when the material was heavy and scrapers were used; under these conditions the dikes were sometimes carried up in benches about 3 ft. in height, but the material was delivered over the sloping edges of the benches by the scrapers in layers not more than 1 ft. thick, and these layers were compacted by the scrapers and horses. When delivered in wagons, a scraper, made of a steel-shod weighted plank on edge, was drawn by horses and the material thus compacted in thin layers. Particular attention was given to the removal of vegetable material, including the sod under the base and over the places whence earth was to be borrowed, and this sod was used for the 6-in. thick earth covering of the dikes. Generally, men were kept on the embankments to remove any roots brought on by the scrapers. Whenever new earth was to be placed on an embankment which had been sun-dried or otherwise hardened, as, for instance, when two sections made at different times were to be joined, the hardened surface was thoroughly ploughed up to insure an intimate mixture and close joint. Wherever the base of such dikes is solid, a berm 10 ft. in width is sufficient; but where much sand or light soil occurs it is advisable to make the berm wider, although a longer haul is thus incurred. Fig. 2 shows the base of a part of the dike cleared of sod and ploughed up ready for the embankment. Scraper cuts of 6 or 8 ins. were generally sufficient to remove practically all of the sod and grass roots from the base. Fig. 3 shows a nearly finished section near the curve at the mouth of Post Creek with lengths of 3 ft. cast iron drainage pipe ready to be laid. The dike is about 14 ft. high at this point. A part of the low dike along Cutler Creek is seen in Fig. 4. In the foreground the sod covering of this gravel is plainly shown. The creek is dry during parts of the year, and at other times a torrent. Between the Erie bridge and the mouth of Post Creek all trees were cut level with the surface of the ground and all bushes were grubbed up; below this point the trees and bushes were cut level with the ground.

The seven streams flowing into the river were taken care of in different ways. Four of them could be carried in closed conduits, extended until the land ends were above high-water mark. One of these four was of brick, 7 ft. in diameter and

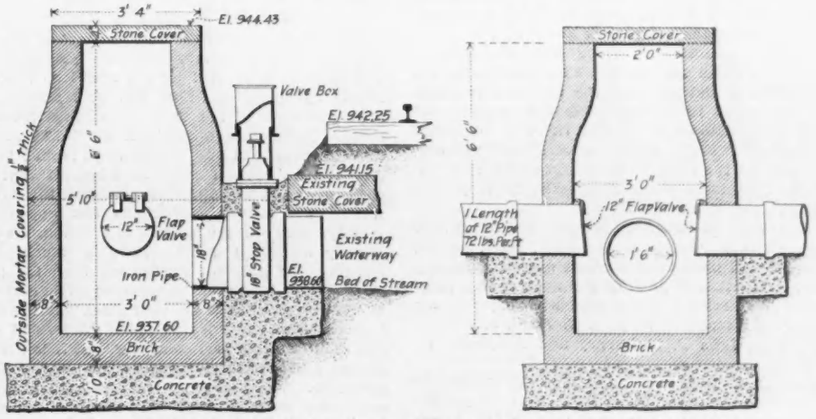

FIG. 7.—CATCH BASIN TERMINAL OF CULVERT, SHOWING CHECK AND GATE VALVES.

500 ft. long; another was of brick, 4 ft. in diameter and 160 ft. long. The river end of this conduit is shown in Fig. 5. As illustrated, a stone cut to the invert curve, let into the brickwork and held in by steel rods 6 ft. in length, prevents the brickwork from ravelling at the end. A third conduit, about 1,000 ft. long, was made of vitrified pipe 1 ft. in diameter, with leaded cast iron pipe under the dike. Two of the other streams were carried through the dikes in leaded cast iron pipes, one of 2 ft. and one of 3 ft. diameter. At the river end of these pipe lines is a flap valve similar to that illustrated in Fig. 6, and under the dike a slide valve is provided. The seventh conduit of stone had to take drainage from both directions along a railway track; its end could not be carried above high-water mark, and it was therefore terminated in a brick catchbasin, shown in Fig. 7, into which extend from two opposite sides cast iron pipe with flap valves inside the basin. A slide valve is also provided for this conduit, which in times of extreme flood will be closed and the surface drainage retained during the

Fig. 6.—Automatic Flap Valve at End of Pipe Line.

greatest flood heights. To carry surface drainage 13 lines of leaded cast iron pipes were used, 11 of them each 1 ft. and the other two each 3 ft. in diameter. These lines also have flap valves on their river ends, and slide valves distant one or two lengths of pipe from their land toe. Brick manholes were placed around the gearing of the slide valves in the 3 ft. pipe.

A retaining wall, 1,200 ft. in length, was built on the north side of the river, from the Bridge St. bridge westward, to insure sufficient width for a street. The river slope for this distance along the dike had also to be made 1½ horizontal to 1 vertical, and for this reason the dike was paved to a point above ordinary floods. The wall during construction, and without its coping, is shown in Fig. 8. It is surcharged to a point 2 ft. above the top of the coping. The beginning of the paving is shown in Fig. 9. At this point the foot of the paving is infrequently reached by the water during the year and the gravel is very firm; consequently the paving is started several feet above low water in a 3 ft. ditch. Generally, however, oak piles 8 ft. long were driven 5 ft. apart, c.

to c., until their tops were below low water, and a line of 12 x 12-in. hemlock sticks, drift-bolted below low water to these piles, forms the foundation of the paving. The dikes are paved to the top for a distance of between 50 and 80 ft. in length above and below each bridge abutment and at the Glass Works. There are thirteen such places, and a length of about 500 ft. on the north side near the Erie bridge, where the current is turned toward the bank, is also paved to the top. The following extract from the specifications shows the character of the paving, which was partly determined by conditions existing in local quarries:

Local stone, of quality approved by the engineer, may be used for this paving. No stone will be less than 4 ins. thick, 18 ins. long and 12 ins. in depth. No stone will be greater in thickness than in depth. They will be laid up dry by hand and thoroughly rammed in place. The joints will not be greater than 1 in., and the stones will break joints by at least 6 ins. The paving will not be less than 12 ins. in depth. The contractor will not be paid for any excess in depth over 12 ins."

There is about 54,000 sq. ft., or 2,000 cu. yds., of this paving, costing $2.50 per cubic yard.

The addition of a span at one end of each of the two highway bridges necessitated the support of one end of the old spans and the continued maintenance of traffic while the old abutments were being removed and the new piers built. The new abutments have wing walls which catch the toe of the paving behind them. All of these substructures are founded on piles and grillages, are of large cut stone, and were built under detailed specifications for good work of this character. The bridge spans are of soft steel, and were inspected at the mills, shop, and during erection. In fact, careful inspection was a feature of the whole work, and although the tenders for nearly all of the 26 items composing the system were very low, unusually good work was obtained throughout. Four inspectors were employed during most of the time, and the four members of the resident engineer corps also acted as inspectors during part of the time.

The Board of River Commissioners, as created by the Legislature, is a permanent body, having the care and maintenance of the system. During the construction of most of the work it was composed of Frank D. Kingsbury, who is president; Harry C. Heermans, Stephen T. Hayt, Jr.; Oscar W. Bump, John B. McBurney and Benjamin W. Wellington.

Prof. P. C. Ricketts, Director of the Rensselaer Polytechnic Institute, Troy, N. Y., was the designing and constructing engineer, with W. W. Rousseau, C. E., and C. C. Curtis, C. E., as assistant engineers.

THE DEPARTMENT OF PUBLIC WORKS of the city of New York, says Commissioner Collis, regularly employs 1,692 men, and the department contractors employ 7,047 more, a total of 8,766. As some of the contractors did not make statements of their force Commissioner Collis says that his department undoubtedly gives employment to over 10,000 men, exclusive of those employed by the street railway companies.

NOTES OF A JOURNEY FROM DETROIT TO DULUTH.

Wabash R. R.

In 1881 this road opened its line from Detroit to Montpelier, and in May, 1893, it opened a new line 150 miles long from Montpelier to a connection with the Chicago & Calumet Terminal Ry., to form the final link of a through line with the Canadian Pacific Ry. between Chicago and Montreal, the distance from Chicago to Detroit being 272 miles. It enters the Polk St. terminal station in Chicago over the tracks of the Chicago & Western Indiana Ry. The line is single track, and lies mainly through a level agricultural country, with no large towns, it having been located mainly to secure a direct and short line. On the new portion the minimum curvature is 2°, and the miximum grade is 26.4 ft. per mile. The track is good, but the roadbed is extremely dusty, gravel having been the only ballasting material at hand at the time. The through trains make but few stops and run at high speed, which is maintained uniformly. There are a great many track crossings at grade, all protected by interlocking plants. This road is using a number of long side-dump ballast cars, mounted on four-wheel trucks, and having inclined bottoms.

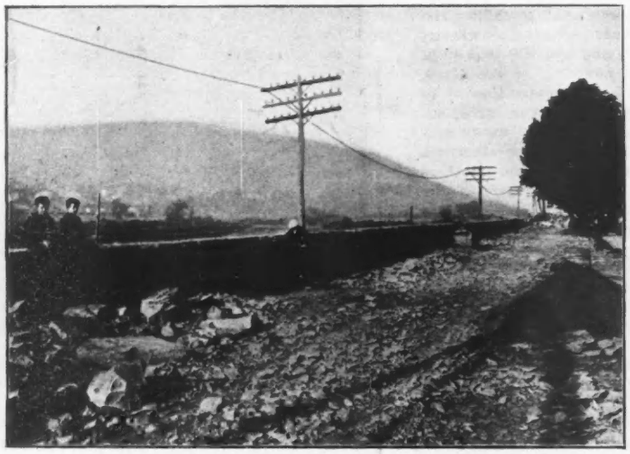

FIG. 8.—RETAINING WALL ON RIVER FRONT; WITHOUT COPING.

FIG. 9.—RIVER SLOPE OF DIKE READY FOR PAVING.

Chicago.

This is now pre-eminently the city of rapid transit, for the electric trolley lines and the elevated railways have invaded the very heart of the city, and there seem to be cable or electric lines on nearly every street in the business center. The elevated railways form very extensive systems, which will soon be connected by the new loop line, the actual operation of which will be interesting to study, in view of the very complicated arrangement of junctions and switches, which has already been illustrated in our columns. In regard to the elevated railways it must be admitted that the spans of the Metropolitan line, crossing the streets, which have curved connections (for appearance mainly) between the girders and columns and a slightly decorated outline, have a much more pleasing and graceful appearance than the plain rectangular girders resting squarely on the columns, which are to be seen on most lines. It has been objected that there is too much "decorated construction" on this particular line, but it is not obtrusive, and certainly produces a far better looking structure. The iron-work is all painted a smoky gray color which is unobtrusive and does not show the soot and dirt which Chicago's atmosphere deposits upon it.

The old and unsafe post-office building has been torn down, and the contract for the pile foundations of the new structure has recently been awarded to McArthur Brothers, of Chicago. Along the lake front are the noticeable improvements in the Lake Front Park, including the raising of the grade of the park and the depression of the grade of the Illinois Central R. R., while beyond the line of the present shore is the completed bulkhead of the new park which is to be formed by filling in the space between the bulkhead and the shore. Contractors for dredging are very anxious to dump cargoes here, but the Park Commissioners have until recently refused permission, the legislature not having given a clear title to the reclaimed land. A good deal is now being heard about the improvement of the Chicago River by widening and deepening its channel, in view of the enormous traffic of the port and the limitations of this traffic by the present capacity of the river. If this work should ever result in replacing the foul, black water of the river by clear water, Chicago would indeed have reason to be thankful for the improvement. The streets are in as bad condition as ever, and the only streets that are kept well paved, cleaned and lighted are the boulevards, which are cared for by the Park Commissioners, and not by the street department. The boulevards are paved with asphalt or macadam, and Jackson St. has just been paved with asphalt to form a continuous asphalt pavement from Jackson Boulevard to the Lake Front. This is as yet the only well-paved street extending across the center of the city. On some streets vitrified brick paving has been laid, with tar grout, and this appears to be wearing well. Among the engineering work now in progress is the elevation of the tracks of the Chicago & Northwestern Ry. and the Pittsburg, Cincinnati, Chicago & St. Louis Ry. along Rockwell St.

Chicago & Northwestern Ry.

This is one of the great railway systems of the northwest, its numerous lines covering a great territory and having an aggregate length of 7,997 miles.

It is one of the few lines having a service of attendants to wait upon passengers at the Chicago terminal station, to assist them with their hand baggage and to furnish information, etc. The value of the service, however, outside of advertising purposes, may be questioned, as the men rarely show any very great readiness, and certainly no American railway has yet established a service giving the civility, efficiency and alertness of the much maligned English "porter."

North of Madison is the extensive work of realinement, reduction of grades and doubling of track which has recently been described in Engineering News, and which has had the result of making this part of the road intolerably dusty. A proof of the practical benefit of this work was afforded by a remark from a trainman to the effect that while the limited express (southbound) was now able to be on time, formerly it was generally from 35 to 45 minutes late, owing to the freight trains being stalled on some of the hills. On this road the importance and expense of gravel trains appear to be properly recognized, these trains being equipped with air brakes and hauled by powerful locomotives. It may be noted that this is one of the few roads which keeps its trains to the left on double track lines.

On the Chicago, St. Paul, Minneapolis & Omaha Ry. (which is a part of the Chicago & Northwestern system) work is in progress between Chandler and Superior Junction, Wis., for reducing the grades and improving the alinement. Mr. Charles W. Johnson, Chief Engineer, states that the new line is 3,100 ft. shorter, and has 139 degs. 52 mins. less curvature than the old line, which will be abandoned. Grades of 42, 51 and 26 ft. per mile, aggregating 18,400 ft. in length, will be replaced by 11,600 ft. of 26-ft. grade on the new line. At Duluth, pile foundations are being put in for a new brownstone passenger station, the plans for which have been prepared. It will be built on land owned by the company, near the Union Station, and will replace the present small frame structure.

Duluth & Iron Range Ry.

This road was built in 1884 by Mr. Charlemagne Tower, but is now owned by the Minnesota Iron Co., which owns the iron mines at Soudan, on the Vermilion range. The original line was from Two-Harbors, on the lake, to Tower, 67½ miles, but it has now been extended 21 miles from Tower to Ely, while a line 27 miles long has been built along the lake shore to Duluth, for convenience in getting supplies out to the mines. All ore is shipped from the company's docks at Two-Harbors. From Tower there is a trail into the Rainy Lake district, and this season a number of prospectors have gone by this route into the new gold fields of that district.

The line is well built and has a substantial track laid with 80-lb. rails, it having been recognized from the first that with the prospective heavy traffic, it would be economy to build a substantial road and so save in maintenance expenses. The upgrades are in the direction of the empty trains, and in the 13 miles from Two-Harbors to Highland there is a rise of 1,150 ft. The equipment includes 24 consolidation engines of 88 tons, and 20 twelve-wheel engines, of 123 tons, the latter being among the heaviest engines ever built. These engines and the ore cars have been illustrated and described in our columns. The ore cars have inclined sides and drop bottoms, and are carried on four-wheel trucks, most of them having diamond trucks, while a few have Fox steel trucks, and a few have tube frames. All these cars are equipped with air brakes (the reservoir being mounted above the sills, under the projecting end of the car body) and M. C. B. couplers. The trains consist of about 20 loaded cars to a consolidation engine, and 26 to a twelve-wheel engine. The passenger cars are very comfortable, and each car has a smoking-room and separate toilet-rooms. This road does not adopt all the regulations of the American Railway Association, but uses red instead of green flags to indicate that a train is following on the same time as the one carrying the markers.

Duluth, Minn.

This great modern city was first established by parties interested in the Northern Pacific Ry. as a rival of Chicago, and is now one of the principal ports on the Great Lakes. It is a long, narrow city, built along the shore of Lake Superior, being 25½ miles long and 2 to 3 miles wide, with an area of 69½ sq. miles. Like many other new cities it is suffering severely from the reaction following upon a "boom," but its prospects are now said to be brightening. A natural harbor is formed by a long narrow spit of land, Minnesota Point, which extends about 7 miles nearly at right angles to the general shore line, and the St. Louis River flows into the bay thus formed. A ship channel has been cut through this point by the U. S. government, and the government maintains a boat ferry across the channel. Several propositions to build a bridge over or a tunnel under the channel have been made, but there is no prospect of any such plan being carried out for a good many years. The harbor is now being improved by dredging, and will eventually have a depth of 22 ft., though the present work is for a depth of 20 ft. This work is being done under an appropriation of $3,000,000, to be expended in four annual portions of $750,000.

Along the upper part of the bay are the extensive ore docks of the Duluth, Mesabi & Northern Ry., coal storage yards (the coal being stored by conveyors in piles enclosed by cylindrical casings of corrugated iron with dome roofs of the same material), lumber wharves, six large grain elevators, sawmills, the works of the American Steel Barge Co. (where the "whaleback" steamers are built), and the coke ovens and extensive steel works of the Duluth Steel Co., whose plant has been shut down for about two years. At West Duluth are the works of the Ironton Structural Steel Co. (S. B. Haupt, President), which are at present idle. This company has made a specialty of a new set of I-beam sections, in which the flanges are more nearly of uniform thickness from root to edge than in ordinary sections, while the reduction in weight between the heavy and light beams of the same size is effected by a uniform reduction in thickness, instead of by a larger reduction in the web. These works have rolled 24-in. I-beams, with 6⅞-in. flanges, 53 lbs. per ft., and can roll I-beams up to 30 ins. in height, with flanges 10 ins. wide.

The railways from Superior cross the bay by long viaducts built on piles, with drawspans over the channels, and these viaducts extend along the shore. The Great Northern Ry. is now replacing its double track wooden approach viaduct with a plate girder viaduct on two-post bents, one-half of the new viaduct being erected while traffic is carried by one track on the old viaduct. There is also a new railway and highway bridge between Duluth and Superior, designed by Mr. A. P. Boller, M. Am. Soc. C. E., of New York city, and built by the Pennsylvania Steel Co., of Steelton, Pa. It was opened July 13. The draw span is among the longest ever built, being 493 ft. long, with two waterways 200 ft. wide in the clear; it is operated by a 50 HP. street railway electric motor, the motor and gearing being in duplicate. The end latches and locks are also operated by electricity. There are two fixed spans of 300 ft., with bowstring trusses, all the spans being through spans. Between the trusses are two tracks for steam railway service, while the floor beams are extended on each side to carry a roadway (with track for the electric railway) and a sidewalk.

There is but little municipal work in progress, as so many improvements were established during the boom time that residents can hardly afford to pay the taxes. The only important work now under way is the laying of the 42-in. steel water main to the new 60-in. intake, eight miles from the city. This new supply was rendered necessary by the contamination of the present supply by the sewage outlets near the present water intake, and it will be described later in a separate article. A number of streets are paved with cedar block, laid upon sand, macadam or concrete. The average life is seven years, but on Superior St. (the main thoroughfare), where concrete was used, the blocks have already been in use for nine years. In heavy rain storms, the water flowing down the steep hillsides causes considerable damage, and large gutters of brick or plank are laid on the hill streets. An old lake beach, some 400 ft. above the present level of the lake, has been utilized for a drive, an excellent level roadway having been built at very little expense, and this drive extends for several miles above the city. The city has many fine buildings, largely faced with Lake Superior red sandstone, but the city hall, though new, is a small low building of no prominence. The street railway company has trouble in winter from snow drifting on the hillside, and on vacant lots it, therefore, erects snow fences to protect the open street. These are ordinary folding fences, as used in railway service, and are stacked in piles during the summer. The company also operates a double track incline railway to Duluth Heights, the structure being a plate girder viaduct. There are two cars (with a cabin and a roadway for teams) operated by a cable, with a separate cable for emergency.

Madison, Wis.

This is a handsome residence city with a population of about 13,500, and here are situated the state capitol and the University of Wisconsin. The latter has a large number of handsome buildings, including the science, law, dairy and farm buildings, and a large machine shop and chemical laboratory. The university has about 1,500 students.

There is but little manufacturing, and no encouragement is given to industrial enterprises, as the people prefer to keep it a purely residence and university town. The city has fine buildings and excellent roads, and nearly every road is lined with trees, while the use of light brick and the freedom from smoke combine to make a very bright and handsome city. The city is an important railway center, various divisions of the Chicago & Northwestern Ry., the Chicago, Milwaukee & St. Paul Ry., and the Illinois Central Ry. converging at this point, but there are no extensive shops, and the freight yards have been moved outside the city.

There is but little municipal work in progress; but an important question now under discussion is that of the disposal of the sewage. At present the sewage is being discharged into one of the four lakes between which the city is located, but this is already causing a nuisance, and other plans are now being considered. There has been considerable talk about these plans, but the city has not yet taken the enlightened step of putting the matter in the hands of an engineer who has made this subject his special business. A report has, however, been made to the council by a special committee, composed of Messrs. M. J. Hoven, McClellan Dodge, F. E. Turneaure and Allan D. Conover, which was appointed in March to consider the feasibility of obtaining a tract suitable for land disposal, within four miles of the present outlet of the Washington Ave. sewer. As no clean sand exists on the surface, it was concluded that broad irrigation was out of the question, and that special filter beds for intermittent filtration would have to be prepared, and for this purpose an area of 10 to 15 acres will be required at present, or about 40 acres for future development. Investigations of the land available show a top layer of clay 4 to 7 ft. thick, underlaid by a mixture of gravel and clay with some sand (a material not at all suitable for sewage disposal), with small pockets of sand of little value. It is found, therefore, that the quantity of land suitable for the purpose is very limited. The sand deposits are small in area, and very irregular in quality, depth of sand and depth of stripping. All the deposits of any consequence are near the marshes and generally quite low, many being at too low an elevation to be available. The material in the sand ridges about two miles northeast of the city is too fine to be used. The best land available consists of three tracts lying east of the city, and having sand of 0.019 millimeters in size, requiring from 3 to 4 ft. of stripping, and some considerable grading. These tracts aggregate 25 to 30 acres, can be reached by 12,700 to 13,300 ft. of pipe, and can be obtained at $100 per acre for one lot, and $200 per acre for the others. The cost of the necessary receiving tank, pumping station and pipe line, and the preparation of 15 acres of land for use as filter beds, is estimated approximately at $55,000 to $60,000. The report was presented on July 13, and was accepted and referred to the committee on sewerage, the special committee being then discharged.

THE WARRIOR RIVER CANAL, for which the last Congress authorized a survey and which is now being investigated by U. S. Assistant Engineer Joseph Ripley, is intended to give Birmingham, Ala., a water route to Mobile Bay and the Gulf. As proposed, this canal would extend from North Lake, near Birmingham, to the Warrior River, near Tuskaloosa, and thence to Mobile. An actual survey of the route is to be made in September, and upon the forthcoming report will depend the construction so much desired by the people of Birmingham.

A 20 TO 21-FT. CHANNEL THROUGH THE GREAT Lakes and their connecting waters has been completed by the government after four years' work and the expenditure of $3,340,000 on the later projects. A 16-ft. channel was completed in 1881 between Lakes Superior and Huron, when commerce increased so rapidly that a 20-ft. channel was demanded. The new St. Mary's lock, 800 × 100 ft. and 21 ft. deep on the miter-sill, was commenced in 1887, under Gen. O. M. Poe, and officially opened in 1896, after an expenditure of about $5,000,000. The Hay Lake channel in the St. Mary River, which before the improvement was only safe for vessels of 8 to 9 ft. draft, was next deepened to 20 ft. at a cost of about $2,659,000. This new channel was opened in 1894, and was preceded, in 1890, by the improvement of the Lime Kiln Crossing, in the Detroit River, where a 20-ft. channel, 440 ft. wide, was provided at a cost of $704,257. With these larger pieces of work completed, the deepening at other shoal points was ordered by Congress in 1892, and the sum of $3,340,000 was appropriated for the purpose. The benefits to commerce are marked by the increase in traffic, in 1895, of 14%, or 1,866,720 tons, in the St. Mary's River, and 7%, or 1,582,800 tons, in the Detroit River. Other im-

provements still are contemplated for the St. Mary's River, at the Middle Neebish, and contracts will soon be let for deepening and widening this channel from 18 to 21 ft. deep, and from 300 to 330 ft. wide. The river will also be widened to 1,000 ft. at the west approach to the new canal, and the channel at Round Island will be increased in width to 800 ft.

THE RAILWAYS OF THE UNITED STATES IN 1896.

From the advance sheets of Poor's Manual for 1897, the following statistics are taken relating to railway construction and operation in the United States for the fiscal year ending Dec. 31, 1896. The accompanying statement explains itself:

Results of Railway Operations in the United States in 1896.

	Miles.	Miles.
Length of track laid up to Dec. 31, 1896.....		182,600.21
Of which completed to close of fiscal year:		
Reporting operations	178,549.33	
Not reporting operations	2,844.84	
		181,394.17
Completed since close of their fiscal years.		1,206.04
Net increase of mileage of all railroads in the U. S. in the calendar year 1896.....		1,087.75
Mileage of railroads reporting operations in the fiscal year 1896		1,737.57

Liabilities and Assets of the Companies owning the above 181,394.17 Miles.

Liabilities.	Operations—Reporting (178,549.33 m.)	Operations—Not report'g (2,844.84 m.)
Capital stock	$5,290,730,567	$82,457,252
Funded debt	5,416,074,969	45,781,629
Unfunded debt	339,502,302	4,997,697
Current debt	386,382,440	2,931,479
Profit and loss	535,853,808	2,941,524
Total liabilities.....	$11,968,544,086	$139,109,551

Assets.	Operations—Reporting (178,549.33 m.)	Operations—Not report'g (2,844.84 m.)
Cost R. R. and equipment..	$9,953,767,710	$125,728,710
Investments	1,450,418,025	7,238,185
Other assets	231,915,121	558,649
Current accounts	161,396,357	1,124,611
Profit and loss	171,046,873	4,459,396
Total assets	$11,968,544,086	$139,109,551

Statistics of Operations, Fiscal Year 1896.

Miles of railroad reporting traffic statistics, earnings, etc.	180,891.19*
Passenger train-mileage	337,641,115
Freight train mileage	497,248,296
Mixed train mileage	15,785,433
Total revenue train mileage.....	850,674,844
Passengers carried	535,120,756
Passengers—mileage	13,054,840,243
Tons freight moved	773,868,716
Tons freight moved one mile	93,885,853,634
Earnings—Passenger	$265,313,258
Freight	770,424,013
Other	89,894,754
Total traffic revenue	$1,125,632,025
Operating expenses	793,298,269
Net earnings	$332,333,756
Other receipts, including rentals received by lessor companies	104,007,542
Total available revenue	$436,341,298
Payments from available revenue:	
Interest on bonds	$242,415,494
Other interest	7,996,456
Dividends	81,304,874
Rentals, tolls, etc.	59,081,058
Miscellaneous	34,233,688
Total	$425,031,570
Balance—Surplus over fixed charges and miscellaneous payments	$11,309,748

* This total is 2,341.86 miles greater than the mileage owned, this excess representing "trackage."

Note.—The liabilities, gross and net earnings, interest and dividend payments, etc., of the elevated railroads in the state of New York, are not included in the above table.

As compared with the business of 1895, this exhibit shows an increase in each item, except that of earnings per ton-mile; for while there is an increase of 3.04% in the total gross earnings, and 3.23% increase in net earnings, there is a decrease of 2.15% in the earnings per ton-mile. The tons of freight moved increased 2.40% and the freight mileage increased 6% over 1895. The share capital increased 3.7% and the funded debt showed a decrease of 3.17% over 1895, the latter resulting from the many reorganizations that have recently taken place. The cost per mile of all roads making returns, as measured in stocks and bonded indebtedness, equalled $59,732, as against $60,188 for 1895.

In this edition of the "Manual" further special effort has been made to secure greater accuracy in the financial returns and operating statistics of the steam surface railways by not only omitting from the general tabulations the returns of the elevated railways of New York, Brooklyn and Chicago, but also by eliminating about 178 railways chiefly used for switching purposes or operated in connection with other industries.

The city and suburban system of railways is now undergoing an extraordinary development owing to the general substitution of electric for animal traction. But in this year's statement of the operation of these roads the "Manual" omits all lines operated in cities of less than 25,000 inhabitants. This is done because the affairs of these smaller roads are usually controlled by local interests and have little interest to those who refer to the "Manual." For the same reason the statement of indebtedness is omitted for towns of less than 25,000 population.

The statistics of track mileage and rolling stock equipment for the steam surface roads is given for each year from 1880 to 1896 inclusive. This statement may be condensed as follows to show the general growth:

Year.	Steel rails, miles.	Iron rails, miles.	Total miles.	Steel, per cent. of total.	Locomotive engines.	Revenue cars—Passenger.	Revenue cars—Baggage, mail and express.	Revenue cars—Freight.	Revenue cars—Total.
1880.....	33,680	81,967	115,647	29.1	17,949	12,780	4,786	539,255	556,930
1885.....	98,102	62,495	160,597	61.0	25,937	17,290	6,044	805,519	828,853
1890.....	167,606	40,697	208,303	80.4	32,241	22,958	7,253	1,061,790	1,092,241
1892.....	182,858	38,641	221,499	82.6	35,099	26,044	7,830	1,159,040	1,192,920
1895.....	206,546	28,652	235,198	87.8	37,090	27,979	7,891	1,230,817	1,266,687
1896.....	207,619	27,864	235,483	88.2	36,080	24,788	7,839	1,189,927	1,222,554

This statement of 17 years' operation is interesting as showing a general and enormous increase in mileage and equipment, and the change from 29.1 to 88.2% of steel rails in the total mileage. The comparison between 1895 and 1896, however, shows that the operating companies have been seemingly eliminating worn-out rolling stock from the returns, and are thus preparing the way for the purchase of new equipment to meet the demands of more active traffic.

Another table given shows the number of miles of railway constructed and in operation for each year since 1830, when 23 miles are reported. Taken by decades this return would stand as follows: 1840, 2,818 miles; 1850, 9,021 miles; 1860, 30,626 miles; 1870, 52,922 miles; 1880, 93,296 miles; 1890, 166,698 miles, and 1896, 182,600 miles. The years 1882 and 1887 showed the phenomenal, but somewhat unhealthy annual gain of 11,569 and 12,878 miles respectively; an annual growth which has steadily dwindled to 1,688 miles in 1896.

The comparative statement for railway construction in the years 1894, 1895 and 1896 is recapitulated as follows by groups of States:

	Miles. 1894.	1895.	1896.
New England	122.79	94.25	36.30
Middle	251.10	205.40	257.72
Central Northern	556.54	324.36	471.87
South Atlantic	377.85	376.73	219.22
Gulf & Mississippi Valley	160.57	123.33	311.20
Southwestern	353.62	545.61	271.41
Northwestern	206.37	47.83	169.53
Pacific	235.13	204.74	259.47
United States	2,263.97	1,922.25	1,996.72

Statistics of freight traffic for the 13 years, 1884-1896, show that the average receipts per ton-mile have steadily decreased in that time from 1.124 cts. to 0.821 cts., and the average receipts per ton have fallen from 126 cts. to 99.55 cts. The average receipts per freight train-mile, however, have increased from $150.19 in 1884, to $154.94 in 1896; though the average receipts from mile of railway, after reaching $4,663 in 1893, fell from $4,443, in 1884, to $4,259 in 1896. The average number of tons carried per mile of road was 4,278 tons in 1896, as compared with 3,526 miles in 1884; the average haul per ton was 112.07 miles in 1884; 109.49 in 1886, and 121.32 miles in 1896. Passenger traffic for the same period shows equally great changes. The average receipts per passenger per mile have only fallen from 2.356 cts. to 2.032 cts.; but the average receipts per passenger were 49.58 cts. in 1896, as compared with 61.87 cts. in 1884. The average number of passengers per mile of road, after running up to 3,385 in the Exposition year, 1893, was 2,958 in 1896, as compared with 2,956 in 1884; and the average distance traveled per passenger decreased from 26.24 miles, in 1884, to 24.40 miles in 1896.

The gross and net earnings and dividends for these 13 years reflect the other statements made. The net earnings per mile fell from $2,318, in 1884, to $1,837 in 1896; while the percentage of expenses to earnings rose from 65.21%, in 1884, to 70.48% in 1896. The average interest paid on the bonded debt in 1884 and 1896 was 4.66% and 4.43%, respectively; but the average dividends paid on share capital fell from 2.48% to 1.54% in these 13 years.

THE BAKERSFIELD POWER PLANT.

By Jas. D. Schuyler, M. Am. Soc. C. E.

(With Full-Page Plate.)

On March 16, 1897, the writer took advantage of an opportunity offered to visit an interesting hydro-electric power plant which has recently been completed for lighting the City of Bakersfield, Cal., and for supplying the town and the neighboring country with electricity for power, as well as light. Not having seen any mention of this enterprise in any of the technical journals, he has assumed that a few notes to accompany the views herewith sent may be of interest to the readers of Engineering News.

The plant has been constructed by the Power Development Co., of San Francisco, a corporation organized with a capital of $500,000, with Chas. Webb Howard as President, and C. N. Beal, Secretary, Treasurer and General Manager, and has cost $150,000. It utilizes a portion of the power available at the mouth of the canyon of Kern River, 16 miles east of Bakersfield. A flume, 8,500 ft. in length, has been built along the precipitous slopes of the canyon on the north side, terminating at the penstock, whence a riveted steel pipe, 66 ins. in diameter and 600 ft. long, leads to the water wheels, with a total fall of 193 ft. The flume is 8 ft. wide, inside, 6 ft. in height, and has a uniform grade of 5.28 ft. per mile. It is intended to carry but 5 ft. depth of water, at which its capacity is computed at 170 cu. ft. per sec., a very conservative estimate, evidently, considering the smooth and uniform interior construction of the flume. The theoretical power, from 170 cu. ft. per sec., falling 193 ft., would be over 3,700 HP., of which 1,300 HP. net is utilized by two generators, and provision has been made for the addition of a third generator of 650 HP. capacity, when desired. The wheels employed are four in number, two to each generator, and are of the type known as the Girard, interior impact, impulse wheels (manufactured in San Francisco), to which the generators are directly coupled on the same shaft. The current is generated at a voltage of 500, and transformed to 10,000 volts for transmission to the sub-station at Bakersfield. The line consists of 6 wires, No. 4 B. W. G., with 26-ft. sawed redwood poles placed 125 ft. apart, planted 4 ft. in the ground. The direct distance by the pole line is 14 miles.

The electricity is to be sold to consumers at wholesale, and, aside from lighting the city, the power will be used for an electric railway and for sundry manufactories. It is expected that advantage will be taken of the cheap power for pumping water on a large scale for irrigation purposes. The ground water level in the delta of Kern River, after 30 years of irrigation, has risen to within a few feet of the surface, and, therefore, the pump lift will be insignificant and the cost of pumping comparatively cheap. Wherever coarse gravel subsoil can be found, the supply from this source should be considerable in volume.

It may be incidentally noted that the question of supplementing and extending irrigation supplies in the arid region by pumps electrically driven is receiving increased attention, and is regarded as a promising field for the utilization of cheap water power, transmitted by electricity.

The most notable feature of this construction is the flume, which is quite unique in plan and general design. The sides and bottom of the flume are formed of inch boards, covered with P. & B. asphalt-coated building paper, which in turn is

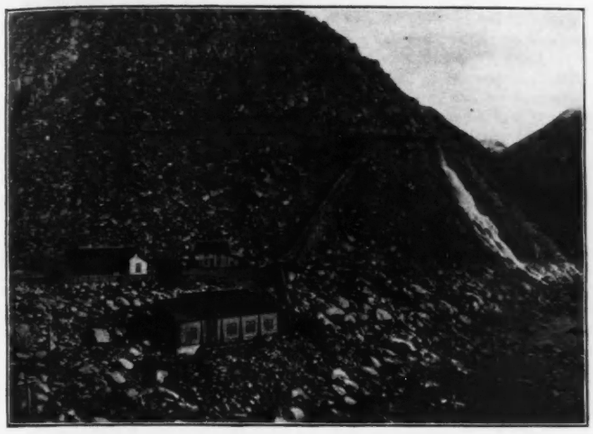

FIG. 5. PIPE LINE AND POWER HOUSE AT LOWER END OF FLUME.

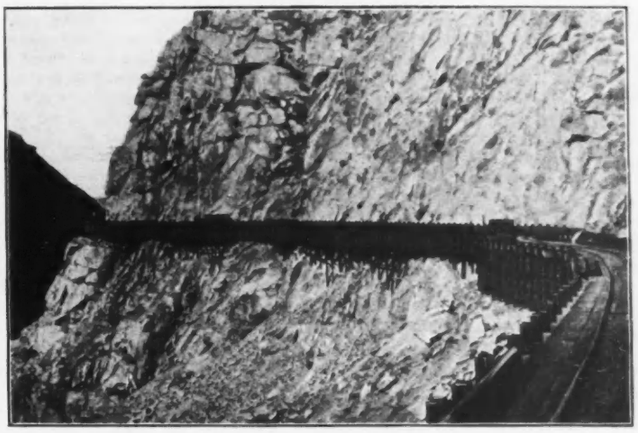

FIG. 3. A PIECE OF DIFFICULT CONSTRUCTION.

FIG. 4. TIMBER ARCH BRIDGE OF 61 FT. SPAN. (ARCH BUILT UP FROM 1-IN. BOARDS.)

FIG. 2. A VIEW IN THE INTERIOR OF THE FLUME.

FIG. 7. PUMPING WATER WITH UNDERSHOT WHEEL FOR USE DURING CONSTRUCTION.

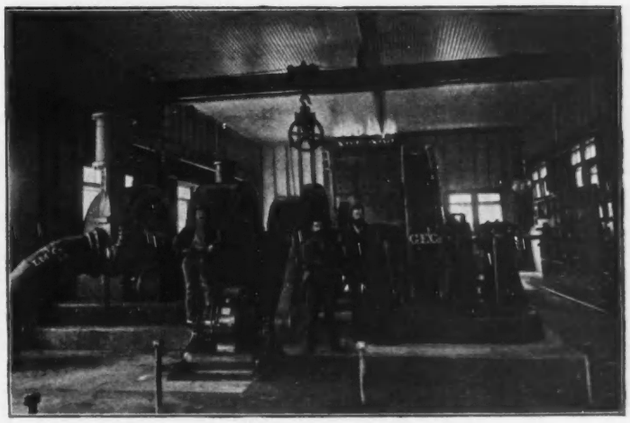

FIG. 6. INTERIOR VIEW OF POWER HOUSE.

WATER POWER PLANT ON KERN RIVER NEAR BAKERSFIELD, CAL.

W. R. MacMurdo, Chief Engineer.
Walter James, Consulting Engineer.

protected by an inner lining of ½-in. boards. The posts are of 2 × 4-in. mountain pine, in pairs, spaced 4 ins. apart, the pairs being 3 ft. c. to c. along the line of the flume. Fig. 1 shows the general mode of construction. The absence of lateral braces to the flume and the substitution of ½-in. rods at every pair of posts, placed 16 ins. above the bottom, and passing through the water from side to side, will be noted as a novelty. These rods are threaded at each end, but not upset, and pass through short 2 × 4-in. plank washers, spanning the space between the double posts. With a small amount of water in the flume covering the rods but a few inches deep, there is a perceptible vibration throughout the flume caused by the impact of the water on the rods; but this is said to disappear when the flume is full, or nearly full.

The use of this method of bracing by means of tie-rods passing through the flume is open to objection where the water carries trash that will find lodgment on them and cause a serious obstruction to the flow of water, and this experience has already been had. The flume, when completed in January, was tested by running water through it before the rods were put in, but the strain of the pressure upon the light posts was found to be rather too great to be considered safe.

In alinement the flume is built on uniform curves of 25 ft. center radius, which admitted of all the lumber being cut to templets, and simplified construction. The floor was first laid on the sills, and shaped to the curvature required by sawing the outer boards. The lower side boards were next spiked in position to the edges of the floor boards, and then the posts were erected by spiking them to each side of the 4 × 6-in. sills, snugly against the outside of the side board already placed, or rather against the 1 × 8-in. boards standing vertically inside the posts, and spanning the space between them, as well as covering the edges of the posts. The 25-ft. radius was great enough to permit the bending of the side boards to the true curvature, where they are held in place by the nails. There are thus no abrupt angles in the flume, and consequently the water has a remarkably smooth and regular flow. The curved sides are well shown by the view, Fig. 2, which shows a wooden track laid inside with a pony to draw cars of material along it. This plan of construction was changed early in the history of the work for a T-rail track on the top of the flume, shown in Fig. 1, which is covered with 2-in. rough plank, and the rails are spiked directly to the plank. It is, perhaps, needless to explain that the flume was built from the lower end up the canyon, the lumber being hoisted to the line up an incline by steam power and cable, and hauled out on the track laid on top.

Fig. 3 gives an excellent idea of the roughness of the canyon through which the flume is built, as well as the general appearance of the latter as completed. A trail, or narrow bench, about 5 to 6 ft. wide, was cut in the rock on grade. The outer edge of the flume projects over the excavation in many places and is supported by posts, placed as shown in Fig. 1, about 2 ft. inside the ends of the sills. The flume is put together entirely with cut steel nails and spikes, which were adopted after an exhaustive series of experiments on the relative holding power and strength of wire and cut nails. No mortises or tenons were used, nor any screws or bolts other than the long tie-rods.

The redwood lumber used for lining cost $33 per M. ft., delivered at Bakersfield, while the Douglas pine from the Sanger district of the Sierra Nevada Mts. was obtained at a cost of $16, at the same point. Hauling from Bakersfield to the end of the flume cost $2.15 per M. The flume was built entirely with unskilled labor at $1.50 per day, and there were no regular carpenters employed on the works. If a man could drive a nail or saw off a board he was qualified. Considering this fact, the flume is a remarkably excellent piece of construction and leaks very little, the principal leakage being along the rods which pass through the flume. It was difficult to bore the holes to the exact size without producing some leakage.

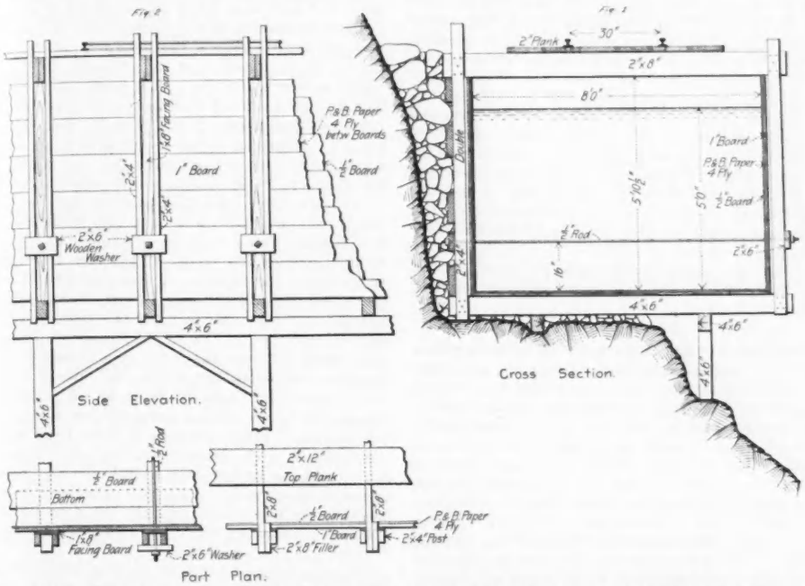

FIG. 1.—DETAILS OF TIMBER FLUME OF THE WATER POWER PLANT AT BAKERSFIELD, CAL.

The entire cost of the flume proper, exclusive of grading, is stated to be $30,000, or about $3.50 per lin. ft., which must be regarded as a remarkably cheap conduit, considering its size and the locality in which it was erected.

Fig. 4 gives a view of the only bridge along the line, which spans a deep, precipitous gulch, in which it would have been unsafe to erect posts on account of rolling stones. This bridge consists of three bowstring girders, made up of 1 × 6-in. pine fence boards, bent into position and spiked together until a depth of 16 ins. was given to the girder. It formed a very cheap and effective bridge, having a span of 61 ft., and a radius of 34 ft.

The binding rods were placed in position after the views published herewith were taken, and, therefore, do not show in any of them. It is believed that every other rod might have been omitted, as the flume is very stiff and rigid. Indeed, it is said that on one occasion all the outer posts were knocked out from under the flume by a falling stone for a distance of 30 ft., with the flume full of water, without causing any undue strain or break in the line.

Numerous accidents have occurred to the flume during construction by stones becoming dislodged from the mountain side, and on one occasion a small avalanche took out about 50 ft. of it, but it is believed that the worst is over in this direction. One stone 10 ft. long and 4 ft. wide, crashed through the plank top of the flume, but did not injure the bottom, doubtless on account of the water meeting it with some velocity. Many cases of this sort have occurred where stones have broken through the 2-in. plank on top, but have not injured the bottom in the least.

The company has been obliged to fill in the space between the flume and the bank solidly with stone and earth as a partial preventive of trouble of this sort, as many stones will be lodged and stopped by this berm that would otherwise break through the flume.

The company has in contemplation the future substitution for the flume of a tunnel 7,000 ft. in length through the solid granite. By utilizing some of the surplus power which they now have developed, the tunnel may be driven at moderate cost, and it can be made of several times the capacity of the flume, so as to utilize more of the power here available, which may be increased by storage of water on the headwaters of the stream.

The flume reaches the river at the head of a cascade, and takes water through a roughly-graded canal without dam or headwork of any sort.

When the works were tested and the water turned on, the latter part of February, the pipe was found to vibrate to such a degree as to be considered unsafe without loading at its upper end, and it was then stripped and surrounded with a heavy masonry cover for some 50 ft. below the penstock. The pipe is made of three thicknesses of steel, in about equal amounts of each, the thicknesses being 0.203, 0.259 and 0.375 ins. It is chipped and calked, double-riveted on straight seams, and coated with asphalt. The top of the pipe is exposed to the weather, the sides being banked up to the center or above the center. Steel cables, passing through eye-bolts in the rock, cross over the pipe about every 50 ft. to anchor it in position. The pipe seems to be entirely tight, and is considered a very satisfactory piece of work. It was made in Los Angeles by the Lacey Manufacturing Co. A general view of the pipe line and power house is shown by the view, Fig. 5, and the interior of the power house is shown by Fig. 6.

The power house foundations are carried to a great depth, with heavy masses of concrete on which the machinery rests, and although the floor of the house is 4 ft. below the high water mark of the great flood of 1868, no subsequent flood has reached as high as the floor, and there are evidences of a deepening of the channel since that time.

The power house is in a frostless thermal belt, where oranges, bananas and tropical fruits will thrive, and a little plantation of this sort has been already started about the superintendent's dwelling, which will quickly take away some of the bleak and barren appearance from the surroundings.

A hot sulphur spring, of considerable local fame, is on the premises, a little way up the canyon above the wasteway, and the water from this spring is pumped by a ram to a tank above the boarding-house and the water is piped to the dwelling.

Ingenious devices have been put in position for opening the waste sluice of the flume, at a moment's notice, by turning a cock at the power house, which operates the piston of a hydraulic cylinder, communicating with the sluice by a wire rope.

The plant is not yet in satisfactory operation, as considerable difficulty has been experienced by the choking of the governor globe valves by the deposit of fine silt from the river water, now at high stage, and various changes in the mechanism have been necessary. If the falling stones continue to give trouble, the projected tunnel may be hastened forward to an earlier completion than was originally anticipated.

The engineer of the work, to whom the writer is indebted for the data herein contained and for the views presented, is Mr. W. R. Macmurdo, of Bakersfield. Walter James, of the same place, is consulting engineer.

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The trustees of the Chicago drainage canal are being subjected to severe criticism by some of the Chicago newspapers because they are letting contracts for work on the tail race of the canal at Lockport, and are pushing proceedings in Joliet to secure the necessary right of way for the channel there. The newspapers claim that this work is being done to develop the water-power and urge that the trustees ought instead to spend their money upon the enlargement of the Chicago River to give the required flowing capacity of 300,000 cu. ft. per minute. Apparently this criticism has no better basis than political jealousy behind it. We are unable to find any justification for it in the actual facts. It is true that the trustees are proceeding to construct a channel through Lockport and Joliet to carry the water discharged from the lower end of the canal; but this channel is quite as necessary to the flow of water in the canal as is the enlargement of the Chicago River. It must be evident to any one that this stream, with a flow of 300,000 cu. ft. per minute could not be turned loose on the hillside at the Lockport terminal of the canal, and allowed to flow where it pleases. A safe channel must be made for it to its junction with the Des Plaines; and below that point the Des Plaines must be deepened and widened so that its channel will carry this additional volume without causing great damage to the property along its course.

If, in making this channel, the Trustees are bearing in mind the utilization of the flow of the canal to develop water-power, and locating their channel in such a manner as to best facilitate this utilization, they are doing what is their manifest duty to do.

A vast deal has been written about the value of the drainage channel for navigation purposes, and very little has ever been said concerning its value for water-power development; but we believe that the latter is of far greater promise than the former. What freight traffic the waterway formed by this channel and the Illinois River may be able to secure in competition with railway lines is problematical; but it is not at all problematical as to how much water-power can be developed by the flow through the canal. That can be computed with great accuracy. Taking the minimum flow of 300,000 cu. ft. per minute, and the total fall from the lower end of the canal to the level of Lake Joliet (75 ft.), and allowing 70% as the efficiency of the turbines installed to use this fall, we have in round numbers 30,000-HP. available. If this were used to generate electric current, every bit of it could be sold to Chicago electric lighting and street railway companies, and would be worth at the lowest estimate not less than $25 per HP. per annum on the turbine shaft. This would mean a return of $750,000 per annum, which would pay the interest on $15,000,000 of the Sanitary District's 5% bonds.

This is the minimum revenue which the city could command from this source. The increase of the flow above 300,000 cu. ft. per minute, to the maximum of 600,000 means an eventual doubling of the above revenue; and it is quite likely that a larger rental than $25 per annum could be secured for the water power. As our readers are aware, we have frequently urged that in estimating the value of a water-power electric transmission plant, the most important point to be considered is the available market for the power. If it can all be disposed of as electric current for electric lighting and railway purposes, a much higher price can be obtained than where it must again be transformed to mechanical power for manufacturing purposes. There is not another instance in the country where so large a water-power is available in such close proximity to a great city as will be the case with the discharge of the drainage channel at Joliet, hence there is absolutely nothing of a speculative nature in the development of the water-power there. The trustees of the Sanitary District of Chicago will deserve censure only if they fail to develop this valuable asset of the District and obtain from it the largest possible return.

Some of our readers may recall an editorial reference some years ago in these columns to a scheme for the multiplication of power, which was at that time being exploited in Bridgeport, Conn., and in Boston, by which an electric current was rapidly switched from one set of incandescent lamps to another and enough of a glow was produced in each set to enable the inventor to claim that he was multiplying from four to six times the amount of light obtainable from a given amount of electric energy. One Geo. B. Pennock has figured as the principal inventor and promoter of schemes of this sort, the fallacy of which was fully shown by several of the electrical journals years ago. After an eventful career in Boston, Mr. Pennock has again returned to New York, and is again exploiting his "volt distributor." A pamphlet just issued by him is such a curiosity that we have allotted it a place in our library on the same shelf with the Argentaurum Papers and Jackson's Treatise on Jet Propulsion.

The outside cover of this pamphlet is ornamented by a photograph of Pennock, "the star of all electricians," as he styles himself, and a quotation at the top reads: "Humanity has always quested after the Marvelous like a hound." We do not know what sage author originally made this remark; but his knowledge of human nature evidently exceeded his knowledge of hounds. Of the "marvelous" statements which the pamphlet contains we have room for only one example:

> A train on the Manhattan Elevated moves; it has momentum, and it is this force that makes it dead easy to multiply horse-power in this way. An electric motor delivers its horse-power, because it receives the electric current. Now, the Pennock System delivers the current so rapidly to a motor that the machine delivers the horse-power. We take the current away and deliver it to another motor and so on to one hundred motors—to one hundred trains—but we always get back with the current to the first train and thus the Pennock system operates an entire railway system at the power cost of one train.
>
> Should Nick Tesla ever complete his oscillator, why, I add my inventions and increase the power a hundred fold. If John Keeley's vibrator ever motes, why I join my automatic negative pole step-back to his engine and duplicate many times its horse-power.

In another place we find the statement that the total "Penns" used for illuminating a certain number of lamps was "about 400," and a footnote briefly remarks that "Penn is a term used by experts (sic) to denote multiplied horse-power!" Evidently Mr. Pennock is determined to hand himself down to fame; but he really ought to define his new unit a little more accurately. If a Penn is a "multiplied horse-power," we ought to be informed what the horse-power is multiplied by, shouldn't we? On further study of the pamphlet, however, this difficulty disappears. By Mr. Pennock's own statement, it is as easy for him to multiply horse-power by 10 as by 2, and as easy to multiply by 100 or 1,000 as by 10. A "Penn," therefore, evidently means x horse-power. We presume that x may also be taken as representing the value of the stock in Mr. Pennock's various companies, and the proper method of finding the value of x in this case is undoubtedly to adopt the method of the calculus and assume x equal to zero.

The New York Rapid Transit railway received what may prove to be its death blow this week at the hands of the Park Board. As our readers will remember, the Rapid Transit Commission some months ago prepared a new plan for a Rapid Transit railway, using Elm St., instead of Broadway, between the City Hall and 14th St., and shortening the uptown lines to reduce the cost of the road to about $30,000,000. These plans have been approved by the Mayor and Board of Aldermen, and are now being reviewed by a Supreme Court Commission in accordance with the law. But this law also requires the approval of the Park Board of the location of that portion of the road which passes under the public parks, and on Aug. 30 this Board refused to approve the plans as filed. Its consulting engineer, Mr. Wm. H. Burr, M. Am. Soc. C. E., reported to the Board that in his opinion a route could be laid out from the loop tunnel under Battery Park, which would affect a smaller number of trees than that selected by the Rapid Transit Commission's engineer. He, therefore, suggested some changes in the alinement of this loop tunnel. Under the terms of the law any change whatever in the location of the road after its approval by the Mayor and Board of Aldermen is claimed to be invalid; hence if the Park Board insists on this change, the Rapid Transit Commission must begin all over again the task of securing the necessary consents. This, however, means a delay which would probably be fatal to the enterprise. Unless the work can be actually put under way before Jan. 1, when the city of New York will be consolidated with the surrounding municipalities, it can not be undertaken at all, for the bonded debts of these other cities will raise the debt of the Greater New York so near the constitutional limit as to make the Rapid Transit road impossible, at least for years to come.

The absurdity of blocking a great public enterprise for the sake of a few trees, which could be replaced bodily for a trifling sum, would be ridiculous if it were not so serious a matter. The "Herald" sets forth the situation admirably as follows:

> ONE OR TWO LARGE TREES IN THE WAY OF RAPID TRANSIT.
>
> "It is a sad state of affairs," said President McMillan, after the vote was taken. "It means a delay of four months. We have got to protect the parks, however."
>
> A sad state of affairs, indeed, if Mr. McMillan and his two associates of the Park Board can postpone for four whole months the adequate rapid transit which the people of this great city are so anxiously awaiting.
>
> And the grounds on which these gentlemen refuse to approve the plans of the Rapid Transit Commission? The loop in Battery Park would destroy some of the trees! An attempt to alter the line so as to save a few trees in that remote vicinity is a pretty reason why the facilities of travel needed by the millions of the Greater New York should be withheld a third of a year longer than is necessary.
>
> As a matter of fact such a delay would mean the total abandonment of the enterprise on which so much thought, time, labor and money have already been expended. Having in view the vast importance of this work to the growth of the city and to the comfort of its citizens, it is difficult to treat with seriousness the objections of the Park Board, based upon the report of their engineer, when he says:
>
> I would suggest that at one point, near the intersection of Whitehall and State streets, it (the line laid down in the plan) be further examined by the chief engineer, with a view, if possible, of avoiding one or two large trees, which are over the site of the proposed structure.
>
> If this sort of stuff can be put forward to delay an enterprise so vital to the prosperity of the metropolis, who can hereafter laugh at the circus clown who stumbles over a pin and is unable to proceed? While we have been pottering over petty obstacles—questioning whether underground roads were feasible, whether they could be properly ventilated, and so on, and laying them out on paper only—other cities have gone ahead and constructed them. Not long since we commented upon the clean, well-lighted and thoroughly ventilated underground electric road in Budapest. The Old World city is now going to build similar lines through a tunnel under the Danube to con-

nect towns on the opposite shores, and at our present rate of progress in New York the trains will be running through that tunnel before we shall have quite decided whether we may sacrifice a laburnum bush in Battery Park or cut off the roots of "one or two large trees which are over the site of the proposed structure."

We presume it never occurred to the engineers of the Rapid Transit Commission in laying out their loop under Battery Park, that they ought to twist it and turn it here and there to avoid the trees!

It is interesting to note at this time that Boston begins this week to run cars through its subway, which was never projected until New York had had Rapid Transit Commissions at work for years. Boston did not hesitate to sacrifice the use of its sacred Common to facilitate the work, rightly judging that rapid transit facilities were of more importance than a few ancient trees. If the New York Rapid Transit enterprise meets the fate which now seems to be in store for it, a suitable epitaph will be: "Strangled with Red Tape."

If the Sunday edition of the New York "Herald" can be relied upon, the board of naval officers appointed to investigate the government dry docks and to recommend improved methods, is sadly in need of some elementary engineering advice. According to the journal quoted, the discussion of this board indicates that it is favorably considering the building of floating docks; and in support of this statement the "Herald" publishes an interview with Commander D. W. Dickins, U. S. N. This officer, in seemingly good faith, advances as one of the great advantages of a floating dock, the ability to send this huge and unwieldy mass to sea and to there "safely" pick up and dock a battleship of the "Indiana" class; and to tow the docked ship back to port. A floating dock, sufficient for this purpose, would measure at least 140 by 400 ft., and be about 70 or 80 ft. deep. The towing of this clumsy and heavy box out to sea would be in itself no light task; but imagine, for a moment, the greater problem suggested by a disabled battleship of 14,000 tons, perhaps down by the head 6 to 10 ft., and listed 20° to port, riding at anchor and waiting to be "docked" in the drifting iron box. In the most favorable weather possible (and when the emergency arises that Commander Dickins suggests there would be no time to wait for calm weather), there would be a swell that would almost inevitably involve both ship and dock in a common destruction. The docking of a battleship is a most delicate operation under the most favorable conditions and in the best and most roomy dry docks. Then, imagine the chances for vital damage involved in deftly slipping the drifting dock under the hull of a moored battleship in a seaway, and lifting up this dock until the keel-blocks take the keel of the ship! Even a layman can appreciate the dangers likely to arise from the slightest bumping together of two such enormous and unwieldy masses. It is safe to assume that a first trial of this experiment, gravely recommended by a prominent naval officer, would be the last—and also the last of both dock and battleship. Commander Dickins is also sadly astray in his estimates of the cost of a floating dock when he says that such a dock "is comparatively cheap at the present time, the cost not amounting to more than $500,000 or $600,000." In the same article in the "Herald" the cost of the floating iron dock, built in 1869, and towed to Bermuda, is placed at $1,250,000, and it is stated that "the annual repair account is $50,000 or $60,000." This Bermuda dock is 381 ft. long and 123 ft. 9 ins. wide over all, and is 74 ft. 5 ins. deep; it weighs 8,350 tons. But this dock, the largest floating dock yet built, is only capable of handling a ship of 6,000 tons; and the somewhat similar dock at Carthagena is limited to ships of 5,600 tons. Commander Dickins will have to revise his estimates of cost for a floating dock of 14,000 tons capacity. The repair account of the Bermuda dock has a significant bearing upon the "comparative cheapness" of this type of construction. As a matter of fact, these docks cannot themselves be docked; and as iron or steel will deteriorate in sea water, the only way of getting at the bottom for cleaning or repairs is by careening by means of the water chambers, an unsatisfactory and dangerous proceeding, that increases in danger with the bulk of the hull to be handled. Finally, for use at the Brooklyn Navy Yard, for example, where is the necessary 50 ft. depth of water to be obtained that a floating dock would demand, and how much would it cost to secure this depth for this "comparatively cheap" dock?

The discouraging feature about this whole dry dock investigation is that the subject is one that can only be properly handled by experienced and able engineers, and there is not an engineer upon the board, or seemingly interested in the discussion of past structural methods or proposed improvements. Even Naval Constructor Dashiell, an undoubtedly able man in his line, has achieved reputation as an ordnance expert only, and has no practical knowledge of dock design or construction. Commodore Bunce and Commander Chadwick, the other two members of the board, do not even profess to have any engineering training or knowledge. And if, as the "Herald" says, Commander Dickins is slated to succeed Rear Admiral Matthews as Chief of the Bureau of Yards and Docks, there will be another case of attempting to fit a square pin in a round hole—to head a purely technical bureau by a man who has shown his dense ignorance of even elementary engineering matters. When will our government gain some wisdom from the ordinary methods of the outside business world, and place its technical affairs in the hands of men fitted by education and training to successfully handle them?

NEEDED REFORMS IN THE PATENT LAWS.

We have had occasion several times to commend the progressive spirit manifested by the National Association of Manufacturers, and the energy with which it is undertaking the extension of American export trade and other work of importance to the manufacturing interests of this country. At the second annual convention of the Association, held last January, considerable attention was given to the subject of patents and patent laws. The executive officers of the Association have since then taken this matter under advisement and have appointed a special committee to investigate this matter, and report with recommendations at the next annual meeting. This committee consists of Messrs. P. W. Gates, C. F. Quincy and Wm. C. Barker, and it has just issued a circular letter asking opinions on various questions in connection with the patent laws to guide it in its work.

Probably there are few matters of governmental policy on which a greater variety of opinions could be found, and the reason is that nearly every man who has an opinion on the subject at all bases his opinion on his own personal interests and personal experience. The patent solicitors, especially those of the "shark" order, want any scheme adopted that will bring more fish to their maws. The inventor favors whatever he thinks will benefit him, the grangers want to see the whole system abolished, and the manufacturers are of many minds, some urging that they want to be freed from the trouble of infringement suits, and others declaring that the great trouble is that patent litigation never brings the successful party enough returns to pay for its cost.

Under these circumstances the committee will have no easy task, we apprehend, in sifting the mass of suggestions which will probably be showered upon it. In accordance with the committee's request, however, we will review seriatim its list of questions, and may preface our remarks by stating that our aim in studying the matter is to ascertain what will be for the best interests of all parties concerned.

1. Should the government not charge an annuity on patents, trade-marks, copyrights, etc., in order to invalidate such patents as are not considered by the owners of sufficient value to warrant the annuity, but which, nevertheless, stand a menace to new and useful patents for fear of infringement. A very large proportion of the patents in force are of little or no value to their owners and are not being made use of, but they, nevertheless, are often found to contain some element making it necessary to procure their control in order to avoid possible litigation or infringement by patents of later date, the merits of which make them desirable to work, both for the owner and the public.

It was suggested that a small annuity would clear from the field such patents as the owner did not consider of sufficient value to warrant the outlay, and at the same time furnish an income to the government which might be used to advantage in the Patent Office.

We do not know that there is any serious objection, so far as the inventor is concerned, to the requirement of an annuity, or small annual tax, upon a patent after it has been in force for three or four years. If the owner of a patent has not begun its commercial introduction by that time, there is little chance that it will ever be put into use; if he has it on the market and is making a profit, he can generally afford to pay the tax.

Undoubtedly a small annual tax would invalidate a large majority, probably nine-tenths of the patents now in force, and if this is a thing which is to be desired, by all means let us have the annuity. But we are not at all clear that the annulment of these unworked patents is a thing to be desired. There are undoubtedly occasional cases, such as those suggested by the committee in the paragraph quoted above, where the holder of a valid but unused patent may refuse to sell or lease his rights to the holder of a later patent who is in position to work it. But cases like these are the rare exception. It is the much more common experience that the manufacturer who desires to exploit a new invention and finds that he will infringe a prior and broader patent, would greatly prefer that this patent be still in force, for then he could purchase it, in all probability, and thus largely increase the strength of his own patent. Another case which frequently occurs is that a patent is obtained on a device to accomplish a certain end. In order to make this patent of much value, its owner tries to patent every other possible device for securing the same end. He will probably find that some of these devices have been already patented; but if the patents are still in force and unused, he can probably purchase them, whereas if they have expired, the public can at any time adopt the alternative device described in the prior patent.

We shall return to this subject later, but we will turn now to the committee's next proposition:

2. The fact that foreigners are allowed to procure patents in this country and hold them without further expense or trouble than the first cost, while our citizens are obliged to pay annuities in many foreign countries, often amounting to many hundreds of dollars during the life of the patents, and also in many cases being obliged to work the same at intervals, entailing further great expense, was commented upon, and it was suggested that laws should be passed making annuities and working obligatory on all patents granted to foreigners the same as their respective governments charge our citizens.

It is true that most of the foreign countries charge much higher fees than the United States, and in many cases assess annual taxes, and require the commercial working of patents to secure their validity; but these fees and restrictions are the same to their own citizens as to the citizens of foreign countries. It is one of the best achievements of modern civilization that it has recognized the great fact that property in ideas knows no national bounds. In all civilized nations it is recognized that the author or the inventor has a property right in his idea, no matter what the country of his birth or his residence. For the United States at the present day to ignore this principle and discriminate against citizens of other nations in its grants of patent or copyright protection would be a long step backward, and one which this nation could by no means afford to take. Even if such a procedure as is proposed were not to be condemned on general principles, we cannot think of a single desirable end which it would secure. Suppose we did assess the same patent fees that are assessed in Great Britain on patents issued to British subjects; the patent office receipts might be increased by a thousand or two dollars each year, and they might not, if ways were found to evade the law; but who supposes that such action would have the slightest effect toward securing a modification of the fees charged by the British patent office?

The fifth proposition may better be considered in connection with that just discussed than in its regular order. It is as follows:

5. The practicability or desirability of having an international agreement whereby a patent allowed in one country may become operative in any other country party to the agreement, upon payment of proper fees, and also to fix upon a uniform charge and practice in relation to government fees, annuities, working, etc.

Desirable? Yes. Practicable? No.

The difficulties of securing an international agreement on even a simple subject are well known; to secure an international agreement on

the subject of patents would mean such an enormous revolution in patent laws and in property rights in patents, that it is idle to expect that agreement could be secured. Moreover, while such an international union might have some advantages, they would not after all be so very important. If an ideal patent system were established in all countries alike, great benefits would unquestionably result; but any matter of international agreement must of necessity be arrived at by mutual concessions. We should in all probability have to sacrifice some excellent features of our own present patent system in order to induce other nations to conform to a single international standard, and would lose in this way more than we would gain.

3. The advisability of having separate courts for adjudication of patents, trade-marks, copyrights, etc., and if not, whether any changes should be made in the present procedure in order to shorten the time necessary to litigate.

Emphatically something should be done to reform present practice in patent litigation; but what this should be, it is difficult to say. The plan of separate courts for the trial of patent cases certainly has merit, and if their procedure could be so simplified, and, above all, accelerated as to reduce the cost and shorten the time necessary to recover damages of an infringer or adjust conflicting claims, it would undoubtedly be an enormous boon to every one in any way interested in patents and manufacturing under patent protection. It will occur to many that such separate courts could have judges of thorough scientific education and specially versed in patent law and patent practice. Even if no separate courts for the trial of patent causes were established, we believe that the present practice under which almost every patent case is tried twice over, first before the Circuit Court and then before the Court of Appeals, should be remedied. The first court is as competent to ascertain the merits of a case as is the second, and the present system which practically compels every patent litigant to try his case twice over ought to be abolished without delay.

4. The desirability of any change in the Patent Office proceedings relative to procuring patents.

The greatest need in the Patent Office at present is a larger and better-paid force and better accommodations for its work. We believe that the present Patent Office staff does wonders in the way of thorough searching in passing upon the applications before it; but it has more work put upon it all the time than it can possibly do and do as well as it ought to be done. A vast amount of work ought to be done in the preparation of classified digests to facilitate the work of examiners; and the delay in passing on applications in many cases is a nuisance which should be remedied.

6. What action, if any, can you suggest that this government should take with countries that allow goods to be imported and sold within its borders that are marked or represented as having been manufactured in the United States, and sold under American names, trade-marks and brands, but which in fact, were manufactured in some country other than the United States?

We mildly suggest that this government shall not take any action whatever unless it is prepared to prohibit American manufacturers from using foreign names, trade-marks and brands upon their goods sold in this country, and to prohibit the importation of goods bearing trade-marks and brands other than those belonging to the country of their manufacture. Probably nothing would more stimulate the imports of foreign manufactured goods into this country than to require them to be stamped with the name of the country of their origin. The girl who would not prefer a ribbon made in Lyons to one exactly like it made in Paterson would be a rare exception.

This, however, is really a matter by itself, and has little to do with the subject of patents. If the committee really wishes to do something in the field of trade-marks, we suggest that it secure an amendment to the trade-mark law which will remedy the defect revealed in it by a court decision some years ago, since which time the registry of trade-marks has practically ceased.

Returning now to the general subject of our patent system, we believe that more important than any and all the reforms which the committee has suggested is a radical innovation in the whole theory of our patent system, which must come sooner or later, and which will be of incalculable benefit when it does come.

Our present patent system is based on the theory that the inventor is a discoverer, and that such discovery is to be fostered and encouraged by granting to the inventor for a limited term of years the sole right to control the use of his discovery. We do not question the correctness of this principle; but we believe that at the present day something more than this is needed. The inventor who originates an improvement is no more deserving of protection and encouragement than is the business man who develops the invention and who teaches the world to adopt it and reap its advantages.

An inventor conceives an idea of a new device, spends a few leisure hours in putting on paper and secures a patent upon it. A manufacturer spends thousands or tens of thousands of dollars in testing and developing the device, in providing special plant for its manufacture, and in advertising it and making it known. For years, perhaps, he conducts the business at a loss, while the conservatism and prejudice of those who still cling to old-fashioned ways is being overcome, and if the invention is a meritorious one, it finally reaches the stage of general adoption.

In view of the above facts, is it not entirely clear that educating the public to the economy and advantage of a new device is of greater importance than its invention or discovery? No great invention, no matter how beneficial to the world, ever markets itself. The public does not adopt improvements merely because they are improvements, but because they are diligently brought to its attention, and all their advantages are made manifest. The vast industrial progress which is the wonder of the century is due, in some degree at least, to the fact that for the first time in the world's history the man who would teach the world how to do a thing better than it was done before has had held out to him the promise of a rich reward.

But at the present time, our future industrial development finds itself hampered by a new cause. Our patent system still protects the discoverer; but there is no protection in it for the man who would take an old idea, patented years ago, and teach the world its merits.

In the United States alone over half a million patents have been granted. Suppose an inventor conceives the idea of a new device, which promises to be exceedingly useful and beneficial. He endeavors to secure a patent on it, but he finds that the same thing, or if not the same thing, something embodying the basic ideas, was patented so long ago that the patent has expired. He can either obtain no patent at all, or at best he can secure only a set of very limited combination claims, which a competing device could easily evade. The result is that no one will put their money into the development of the device, and one more is added to the list of "sleeping" patents.

We believe that there are hundreds and thousands of improved processes and devices which would be brought into use to the vast benefit of the public, if the patent system were so amended that expired patents on inventions which have never been put into commercial use, should be made no bar to the granting of a new application for the same thing, of course under proper restrictions.

Whose interests would be injured by such an amendment? Not the inventor's, for he continually finds that some obsolete and unworkable device in an expired patent contains just enough of his invention to prevent him from securing a broad claim. Not the manufacturer's, for he can then secure patents as a basis for new industries and improvements which will be broad enough to make him safe from infringements. Not the public's, for it is for its interest above all that industrial progress and improvement should go on unhampered. The ideas contained in expired and unused patents are as effectually buried, so far as any good the public receives is concerned, as if they had never been discovered and recorded. We may liken them to a valuable mineral deposit, which can only be reached by sinking a deep and expensive shaft. If no one can secure a title to the ore deposit, the shaft will never be sunk; for any one would be foolish to expend a large amount of money to reach the mineral vein if every one who chose was at liberty to use the finished shaft and help himself to the ore.

We are aware that the proposal we have made is entirely revolutionary and unprecedented, and that it runs counter to the old theories respecting patents and patent protection which are still in force in nearly all civilized countries. Nevertheless, we believe that it is a change which must sooner or later be made, and its justice will be recognized when people come to understand that the profits made from patented inventions are not so much rewards to the inventor as rewards to the business sagacity and enterprise and skill which recognizes the merit of the invention and invests large amounts in educating the public in the economy to be gained by its use.

LETTERS TO THE EDITOR.

An Early Proposer of Steel Rails for Common Roads.

Sir: I have been much interested in the recent experiments undertaken to demonstrate the advantages of the use of flat iron rail on public roads and the streets of small towns.

In 1881 Dr. Thos. D. Hogg, of Raleigh, advocated the use of rails in the streets of Raleigh, and as far as I know he was the pioneer in this field. I enclose a part of a pamphlet published by him in 1881, with those portions in regard to the rail marked. In his newspaper articles Dr. Hogg went at length into details of his road, specifying the kind of steel, the method of paving, etc.

Very respectfully, F. H. Busbee.
217 Fayetteville St., Raleigh, N. C.

(The pamphlet sent by our correspondent is an interesting exposition of a proposal to lay steel track cartways in all the streets of the city of Raleigh which are subjected to heavy traffic. The writer of the pamphlet proposed a flat steel rail laid in a narrow macadam roadway, and outlines in considerable detail plans for its construction and for raising funds to pay for it. He also brings forward a proposition which has been considerably agitated anew within a year or so, and which possesses no small merit, viz., to reduce the width of streets and thus lessen the expense of paving them. On streets of 100 ft. width he proposed a grass plot 20 ft. in width in the center of the street, with shade trees along it. On 66-ft. streets he would narrow the roadway to 20 ft. in width, and cover with grass the space between the sidewalk and the curb.—Ed.)

Minimum Compensation for Young Engineers.

Sir: I ask for information on a subject that is certainly of interest to me, and may interest a number of your younger readers.

I am a young engineer, graduate in 1894, and am located in a growing town of about 6,000 inhabitants. There is little engineering work here of a high grade; but much surveying has to be done, and there is the city work of curbing, paving, sewerage and extension of the system of water distribution. In a town of this size this latter class of work amounts to comparatively little, and all of it can be done in four months of the year. The majority of the people, including most of the city councilmen, regard an engineer as a needless luxury, and his employment as extravagance. And the authorities who do believe in the services of an engineer have very vague ideas as to proper compensation.

What I wish to know is the minimum compensation in such cases; both on the basis of a percentage of the total cost of improvement, and a rate per day, including expenses, for preliminary surveys, plans, estimates, specifications and report, and also the rate of superintendence of construction.

I realize that there is a figure, to go below which would be a wrong to the profession. At the same time I think I can afford to work more cheaply than if I had more experience and had established my reputation. Each piece of work successfully performed constitutes an advantageous advertisement for me professionally, and is a source of valuable training.

Yours, respectfully, J. R. S.
Aug. 23, 1897.

(A detailed and satisfactory answer to the queries of our correspondent is impossible, owing to the unknown quantities entering into such an equation. It may be said that no minimum rate of compensation can be fixed for professional services of any class, except by stringent and well-recognized requirements and laws, binding upon both the employer and employed. In the case of engineers no such laws exist; and, as our corre-

spondent remarks, the average employer of engineers is ignorant of the duties required and too inexperienced to appreciate the value of good engineering advice or the cost of bad engineering. Men of this type will always secure their engineers —when they think they need them at all, in the cheapest market; and in so doing will honestly believe that they are fulfilling the trust imposed by equally ignorant and inexperienced taxpayers. And under these conditions the young or needy engineer will continue to give what service he can provide for about anything that he can get for it, in the face of all professional protest and rules of professional conduct that may be formulated. Our correspondent seems to appreciate his position; and while we regret that we cannot give him the figures asked for, we would add that he is on the right road. What the young engineer needs most of all is practice and experience; and he should get this when he can and at the best compensation available. When he believes he has outgrown his field for useful effort, and can convince others of this fact by actual performance, a broader field usually opens and a better compensation can be had. And by a careful study of conditions, close attention to business and absolutely satisfactory work, the engineer can often teach his employers the true value of good work and lead them to a more substantial recognition of his services. In a word, success, which really means compensation for service, depends so much upon individual capacity and effort that no rule or rate of pay can be laid down applicable to all practitioners alike. —Ed.)

Concerning Timber Dry Docks.

Sir: An interesting leader in the current issue of Engineering News mentions the topical subject of dry docks, and suggests a combination of timber and concrete construction "as within the possibilities of engineering skill." Without disparaging the suggested system I would mildly remind you that this is the combination that has given so much trouble in the recent timber dry docks on the Atlantic Coast.

During the past few years the writer has given a large amount of time and study and has completed several designs of dry docks. However, the intention of this note is to point out a few salient facts, and to urge caution in adopting a design of wood and concrete in combination.

The first successful wooden dry dock in the United States was formed from the hulk of an old "merchantman" in Maine; subsequently the late Mr. Simpson constructed (1854) a timber-box dry dock in Boston. A sectional drawing of this dock shows that a substantial clay-filled coffer-dam formed the main walls of this dock. The floor was puddled underneath with clay, and constructed of heavy timbers, reinforced with large braces at the junctions. Heavy braces supported the altars, and the braces sloped from the floor to the sides, stiffening the entire structure. This departure from a masonry design answered its purpose admirably, and its success prompted the subsequent development of timber dry docks. However, it must be said that the successful feature of Simpson's original design has been gradually lost sight of; viz.: the coffer-dam walls and floor, by which the perfect tight box you specify was secured. Vertical rows of sheet piling have since been universally adopted to form the side walls of timber dry docks. Manifestly, this should stop the lateral flow of subsoil water, and perhaps it does; but practically nothing exists in the present designs to prevent the water rising between these rows of sheeting. To this fact certain well-known failures may be directly traceable.

The weak point in nearly all timber dry docks is situated close to the bottom of the altars. Recent designs show this point reinforced by concrete in combination with the wood; yet failures occur. A radical change in the design of timber dry docks must be made before success can be expected in difficult foundations. Some dry docks constructed from patented designs are understood to possess an auxiliary 12-in. centrifugal pump, to take care of leakage water! The writer knows of a timber dry dock that will leak, when emptied, nearly 9 ft. depth of water over the dock floor in a day, in case no auxiliary pump is used.

The 30 or more timber dry docks on the Lakes are in the main successful, perhaps chiefly owing to their usual location in a bed of impervious clay. Whatever foundation is given, it is the duty of the engineer to design his structure in accordance with it.

The life of a timber dry dock will not exceed 20 years without large renewals. You report on page 139 that the Point Levis (Canada) masonry graving dock has "since its opening (1886) withstood the climatic influences without injury from frost." Good masonry is unquestionably more suitable and durable than timber. The sentimental objection to masonry docks on account of a cold and damp atmosphere would be unmentioned if the common experience of "tobogganing the dock" due to the muddy and slimy altars of a timber dry dock had been experienced.

The approximate cost of timber dry docks may be taken at $1,000 per lin. ft. of dock. Foreign masonry dry docks generally cost less, and possess a superior equipment, and facility for docking. The total cost is large in any event. Therefore, the best and most durable design should be adopted. An economical design for a commercial dry dock should not exceed $500 per lin. ft. of dock at present prices.

Your views on floating and sectional docks are eminently sound. It may be pointed out, in addition, that these docks require a depth of water to be maintained for operation equal to the draft of the vessel docked plus the depth of the dock itself, for sinking under the vessel, probably 50 ft. for naval vessels. Respectfully yours,

Robert A. Cummings.

Garrettford, Del. Co., Pa., August 30, 1897.

(It is exactly because the weak point in nearly all timber dry docks is situated close to the foot of the altars, as our correspondent remarks, that we suggested the concrete walls on the timber floor. Both coffer-dams and sheet-piling are difficult to connect with the floor in such manner as to make a thoroughly water-tight joint; and to form the "box" needed, the floor and sides must be well joined. We admit that to substitute concrete for the present timber sills, braces and piles in the sides of the dry dock, and to connect this concrete properly with the floor, means a very considerable increase in cost and a widening of the floor-system to some extent; but if the foundation soil is reasonably good, or piles can be relied upon, the mass of concrete could be reduced by stepping up the base. We are aware that if concrete were used it would have to be faced and covered with stone or timber, to protect it from climatic changes. The disintegration from this cause of the concrete capping of one of the Erie docks shows that concrete cannot be left exposed in this climate. Concrete and timber combined construction was suggested because it was believed that it would make a tighter and more reliable "box" than was possible with the present type of timber dock—or even with the coffer-dam, and because it was cheaper than all-masonry dry dock.—Ed.)

THE NEW YORK STATE CANALS IMPROVEMENT.

I.

Purpose and Nature of the Improvements.

The great work of deepening and otherwise improving the state canals of New York, which was begun early in the winter of 1896, has now reached a stage of progress which enables a pretty complete description of its general scope and character. Altogether 454 miles of waterway, comprising the Erie, the Oswego and the Champlain canals, are being deepened 2 ft. and numerous subsidiary structures, as locks, culverts, aqueducts, etc., are being rebuilt and enlarged to correspond to the deeper channel. In this and succeeding issues of Engineering News, such information as is available regarding the various features of the work will

Fig. 1.—Sketch Map Showing Routes of New York State Canals Now Being Improved.

be given in some detail. This information has been secured by a personal examination of the work at various points by a member of the editorial staff of this journal, and from photographs, drawings and descriptions furnished by the engineers and contractors connected with the construction.

Original Construction and Early Improvements. —With the completion of the improvements now under way, the three canals mentioned above will have been reconstructed twice since they were built, and it will aid somewhat to a clear understanding of the present work to review briefly these former improvements. From an article which was published in Engineering News of Jan. 3 and 10, 1878, the following information is taken: The Erie Canal was completed from Albany to

TABLE I.—CONTRACT PRICES FOR PRINCIPAL ITEMS OF WORK ON 16 CONTRACT SECTIONS OF THE NEW YORK STATE CANAL IMPROVEMENT COMPILED FROM THE OFFICIAL BIDDING SHEETS.

	Eastern Division.							Middle Division.			West'n Division.			
Items.	Gallo & McNiece, New York, N.Y.	Brumelkamp, Lane & Co., Syracuse, N. Y.	Lauer & Hagaman, Rochester, N. Y.	Whalen & Higgins, Waverly, N. Y.	J. W. Whalen, Whitehall, N. Y.	Mahan & Sandstrome, Sandy Hill, N. Y.	Shear & Haight, Schenectady, N. Y.	John V. Quackenbush, Mohawk, N. Y.	T. J. Dwyer & Co., Utica, N. Y.	John Dunfee & Co., Syracuse, N. Y.	Edwin Lodder, Syracuse, N. Y.	O'Brien & Hoolihan, Syracuse, N. Y.	O'Brien & Hoolihan, Syracuse, N. Y.	Donnelly Contracting Co., Buffalo, N. Y.	Chas. F. Parker & Co., New York, N. Y.	Grannis & O'Connor, Syracuse, N. Y.	Average.
Dry excavation: Earth, per cu. yd.	$0.24	$0.30	$0.27	$0.26	$0.28	$0.20	$0.25½	$0.25	$0.27	$0.27½	$0.26	$0.28	$0.30	$0.35	$0.22	$0.23¾	$0.282
" " Rock, per cu. yd.	1.25	...	1.60	...	3.00	.90	1.00	...	1.00	1.00	1.25	1.25	1.53	.82½	3.00		1.45
Rock channeling, per sq. ft.	....	...	...	...	...	...	...	...	.15	.10	.25	...	...	.35	.15	...	.18
Embankment, per cu. yd.	.25	.40	.60	.80	.40	.16	.15	.20	.60	.30	.40	.45	.45	.45	.30	.25	.397
Lining, per cu. yd.	1.25	1.00	1.10	.40	.60	.90	.95	.60	.80	1.00	.75	.70	.70	1.35	2.00	.80	.93
Puddling, per cu. yd.	.50	.25	...	.30	.40	...	.50	.35	.20	.30	.10	.20	.20	.40	.40	.40	.32
White oak timber, plank, per M. ft. B. M.	....	50.00	...	...	...	...	...	50.00	40.00	50.00	60.00	40.00	40.00	39.00	50.00	40.00	45.90
Pine timber, plank, per M. ft., B. M.	....	50.00	...	...	...	...	...	35.00	30.00	30.00	50.00	30.00	30.00	32.00	30.00	40.00	35.70
Hemlock timber, plank, per M. ft., B. M.	20.00	20.00	18.00	18.00	18.00	17.00	17.00	16.00	14.00	16.00	18.00	15.00	16.00	18.00	20.00	17.00	17.30
Spruce timber, plank, per M. ft., B. M.	....	...	...	...	...	...	...	...	20.00	17.00	18.00	22.00	22.00	...	...	...	19.80
Bridge, culvert and receiver, masonry, per cu. yd.	....	8.00	...	...	12.00	8.00	12.00	8.00	6.00	7.00	6.50	7.00	7.00	14.00	10.00	9.00	8.80
Masonry coping, per cu. yd.	....	...	...	...	12.00	15.00	15.00	18.00	12.00	6.00	15.00	10.00	10.00	22.00	30.00	18.00	15.25
Vertical walls, Portland cement, per cu. yd.	6.00[1]	5.00[1]	5.00[1]	4.90[1]	5.00[1]	4.80[1]	5.10[1]	4.70[1]	5.00[1]	6.00	6.00	5.00	5.00	7.00	12.00	5.00[1]	6.00[2]
" " dry, per cu. yd	....	...	...	...	...	...	...	...	3.50	3.50	4.00	3.00	3.00	3.50	2.50	3.40	3.17
Slope and partition wall, per cu. yd.	3.10	2.50	2.90	3.00	3.00	2.80	3.55	3.20	3.00	2.47	2.50	2.25	2.25	...	1.50	2.30	2.68
Portland cement concrete, per cu. yd.	....	...	...	...	8.00	...	...	...	6.00	5.00	5.50	5.00	5.00	6.00	...	...	5.78
Natural " " " "	6.00	6.00	...	4.50	6.00	6.00	5.50	5.00	...	...	...	...	...	5.00	...	5.00	5.44
Loose stone filling, per cu. yd.	....	...	...	...	...	...	...	...	1.00	2.00	.75	.75	.75	1.35	...	...	1.10
Portland cement pointing, per sq. yd.	....	...	...	...	...	...	.25	...	.25	.50	.25	.50	.50	.60	...	...	.41
Wrought iron and steel, per lb.	....	...	...	...	...	...	...	.07	.05	.05	.06	.05	.05	.04	...	...	.053
Cast-iron pipe, per lb.	....	...	...	...	...	...	...	.05	.05	.02	.04	.035	.035	...	.02	...	.035
Spikes and nails, per lb.	....	.05	.06	.04	.04	.05	.06	.04	.04	.05	.05	.03	.04	.05	.023	...	.051
Masonry, lock and aqueduct walls, per cu. yd.	....	8.00	...	...	...	...	...	15.00	...	...	...	7.00	...	...	15.00	...	11.25

[1]Natural cement concrete. [2]Average of natural cement concrete is $5.05.

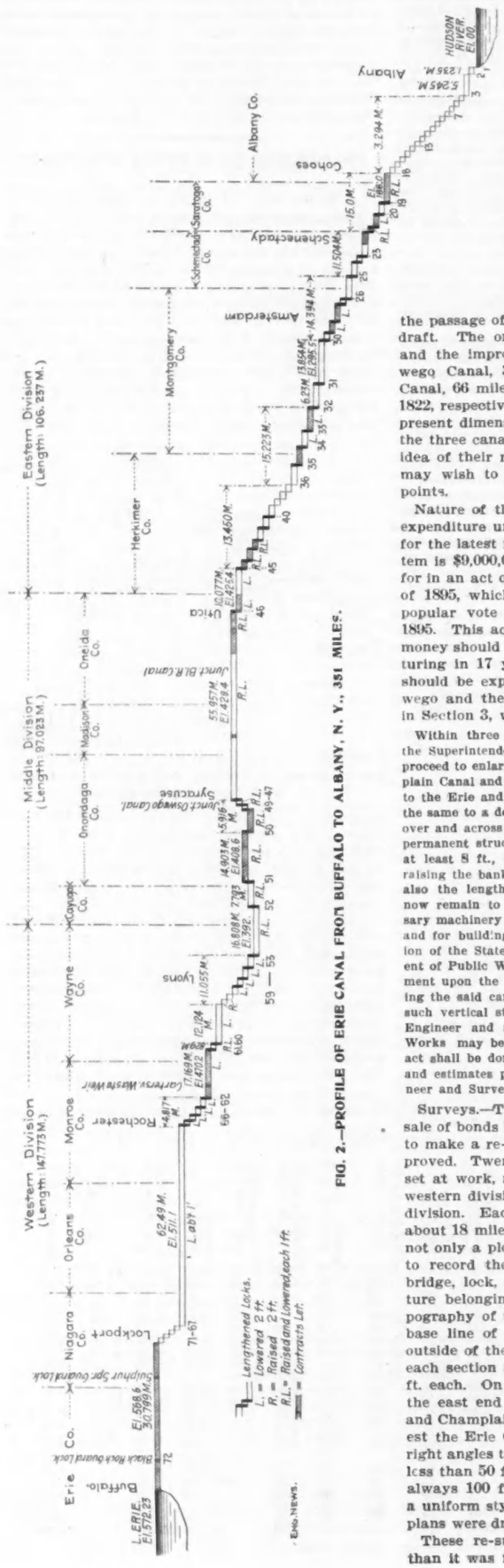

FIG. 2.—PROFILE OF ERIE CANAL FROM BUFFALO TO ALBANY, N. Y., 351 MILES.

Buffalo, N. Y., and put into use in 1825, but it was not formally recognized as being completed until 1836. By that time, however, the traffic had grown to such a volume that it was deemed advisable to enlarge the canal, and accordingly the work was begun the same year the original waterway was formally completed. The original canal was 363 miles long, with a prism 40 × 28 × 4 ft., and 675½ ft. of lockage. The locks were 90 × 15 × 4 ft., allowing the passage of boats of 75 tons burden and 3½ ft. draft. The enlarged canal was 350½ miles long, with a prism 70 × 56 × 7 ft., and 654.8 ft. of lockage. The locks were 110 × 18 ft., allowing the passage of boats of 240 tons burden, and 6 ft. draft. The original construction cost $7,143,789, and the improvement cost $44,465,414. The Oswego Canal, 38 miles long, and the Champlain Canal, 66 miles long, were completed in 1828 and 1822, respectively, and afterwards enlarged to their present dimensions. In Fig. 1 is shown a map of the three canals named, which will give a general idea of their routes and connections to those who may wish to refresh their memories on these points.

Nature of the Present Improvement.—The total expenditure undertaken by the state of New York for the latest improvement of its public canal system is $9,000,000. This expenditure was provided for in an act of the State Legislature in the spring of 1895, which was constitutionally approved by popular vote at the general election of Nov. 5, 1895. This act provided, first, that the necessary money should be raised by a sale of 4% bonds maturing in 17 years, and, second, that this money should be expended to improve the Erie, the Oswego and the Champlain canals, as provided for in Section 3, which was:

> Within three months after issuing of the said bonds, the Superintendent of Public Works is hereby directed to proceed to enlarge and improve the Erie Canal, the Champlain Canal and the Oswego Canal; the said improvement to the Erie and Oswego canals shall consist of deepening the same to a depth of not less than 9 ft. of water, except over and across aqueducts, miter sills, culverts and other permanent structures, where the depth of water shall be at least 8 ft., but the deepening may be performed by raising the banks wherever the same may be practicable; also the lengthening or improving of the locks which now remain to be lengthened, and providing the necessary machinery for drawing boats into the improved locks and for building vertical stone walls where, in the opinion of the State Engineer and Surveyor and Superintendent of Public Works, it may be necessary. The improvement upon the Champlain Canal shall consist in deepening the said canal to 7 ft. of water, and the building of such vertical stone walls as in the opinion of the State Engineer and Surveyor and Superintenedent of Public Works may be necessary. The work called for by this act shall be done in accordance with plans, specifications and estimates prepared and approved by the State Engineer and Surveyor.

Surveys.—The first work, as soon as the first sale of bonds had assured the necessary funds, was to make a re-survey of the three canals to be improved. Twenty-five separate survey parties were set at work, nine parties each on the eastern and western divisions, and seven parties on the middle division. Each of these parties, therefore, covered about 18 miles of canal, and its duty was to make not only a plot and profile of the canal prism, but to record the character and dimensions of each bridge, lock, culvert, and other permanent structure belonging to the canal and to take the topography of the land immediately adjacent. The base line of the survey was placed about 12 ft. outside of the inner angle of the tow path, and on each section it was divided into "stations" of 100 ft. each. On the Erie Canal the surveys began at the east end of each section and on the Oswego and Champlain canals they began at the ends nearest the Erie Canal. Cross sections were taken at right angles to the line of the canal and were never less than 50 ft. apart; the idea being to keep them always 100 ft. apart. The notes were kept after a uniform style and all cross sections, profiles and plans were drawn on uniformly-sized sheets.

These re-surveys proved even more essential than it was first thought they would, although it was known that the old maps and plans were difficult to use and badly arranged, for as the channel was drained and the work of construction began it was found that many changes from the plans recorded has been made in the actual construction, or in subsequent improvements, and no memoranda of them kept. They also gave what the State Engineer's office had never before had, a complete and systematic record of all the state canal structures. The primary purpose of this re-survey, however, was to furnish information upon which the plans and estimates for the improvements could be based.

Plans and Specifications.—The exact plans for various parts of the work can be more clearly described in a future article, where the different constructions are given in detail, and it need only be stated here that they were made as nearly uniform as possible for each class of construction. A general specification was also drawn to cover all parts of the work, and such parts of this as are of general interest can also be given more appropriately in another connection.

Division of the Work.—For the purpose of maintenance the New York state canals have for a number of years been separated into three divisions, each in charge of a Division Engineer representing the State Engineer and a Division Superintendent representing the Superintendent of Public Works, and the same form of administrative system was adopted for the improvement work. As shown by the profiles of the three canals being improved, which are given in Figs. 2, 3 and 4, the Eastern Division comprises the Champlain Canal, 65 miles long, and 106 miles of the Erie Canal west from Albany; the Middle Division comprises 97 miles of the Erie Canal, and the Oswego Canal, 38 miles long; and the Western Division comprises 147.7 miles of the Erie Canal, and the Hamburg Canal, in the city of Buffalo. The mileage of canal included in the improvement under discussion in the three divisions is, therefore, 171 miles, 135 miles, and 149.4 miles, respectively.

The profiles, Figs. 2, 3 and 4, show the length of each level, the location of each lock and whether it has been lengthened or not, the sections now under contract and construction, the names of contractors and the location of their work, the method of deepening adopted, and various other details of the work as a whole, and should be consulted for such information. These profiles have been drawn from the official plans of the State Engineer, and are thus compiled from the latest surveys.

Contractors and Contract Prices.—The necessary preliminary work was completed so that bids for construction were called for Oct. 29, 1896, and shortly thereafter contracts for work amounting to about $4,000,000 were awarded. The canal was closed to navigation Dec. 1, 1896, and soon after work was begun and continued vigorously until May 5, 1896, when navigation was opened and all contractors not through with their work or not intending to use dredges, discontinued operations until the coming winter. As was previously noted, the names of the contractors and the lengths of their contracts are given on the profiles, Figs. 2, 3 and 4. Altogether about 25 contractors obtained work on the canal at the first calling for bids.

Anything like a terse statement of the contract prices is pretty difficult, as the bids were all itemized and there is a wide variation in the number and character of the items on different contract sections. To give a general idea of the cost of work, however, we have tabulated the prices bid for the more common items of work on 16 contracts, covering about 60% of the mileage now under construction or completed. The cost of a number of other items which occur only a few times on the work will be given in another place where this work is described.

Referring to the table, it will be noticed that a column of averages has been introduced. These, of course, should be studied with the limitations of the figures well in mind. It is interesting to note, however, that excavation in dry earth has cost 28 cts. per cu. yd., and excavation in rock, $1.45 per cu. yd. On the Chicago Drainage Canal the average cost per cubic yard of these two items of work were 28.9 cts. and 76.3 cts. While the rock work on the Drainage Canal has been done considerably cheaper than on the present work, as would naturally be expected, in earth the advan-

tages of the larger mass of material and limited area of operations on the Chicago Canal, which of course permitted the use of steam shovels and other power excavators to the best advantage, were counterbalanced by the hardness of the material, great cost of plant and high wages, as compared with the Erie Canal work. It is also rather interesting to note that the cost of natural cement concrete only runs about 34 cts. per cu. yd. lower than Portland cement concrete, while there is 95 cts. difference in the prices charged for vertical wall masonry laid in natural and Portland cement mortar. Other features of interest will be seen upon an examination of the table.

ASPHALT AND ASPHALT PAVEMENTS.*

By George W. Tillson,† M. Am. Soc. C. E.

Asphalt.—The bitumen which forms the base of asphalt is defined by Prof. S. F. Peckham as "that large class of substances occurring in Nature as minerals and consisting chiefly of mixtures of compounds of carbon and hydrogen, with nitrogen, sulphur and oxygen as more rare constituents." In this paper bitumen will be considered as any natural hydro-carbon soluble in carbon bisulphide, and any substance containing hard bitumen will be called asphalt. Of the bitumen itself, the portion soluble in ether is called petrolene, and the remainder soluble in chloroform or carbon bisulphide, asphaltene. For an asphalt suitable for paving, the bitumen should contain not more than 20% or 30% of asphaltene.

The amount of bitumen in asphalt is not so important as regards final results, but its relative quantity influences the commercial value of the asphalt in consequence of the cost of handling and refining it, and particularly in consequence of the effect it has on the number of yards of pavement that can be laid per ton of crude material.

This bitumen is of varying quality, and upon its character depends the value of the asphalt for paving purposes. The petrolene gives the cementing property to the asphalt, while the asphaltene forms the body of the material. If an asphalt contains too much petrolene, it is soft and sticky and makes a sticky pavement. If the asphaltene be in excess, the pavement will be hard and liable to crack and disintegrate. The petrolene is the solvent for the asphaltene and must be added to a hard asphalt in such quantities as will give an asphaltic cement of proper viscosity. Upon the preparation of this asphaltic cement depends the success of the completed pavement.

According to Boussingault the formula for petrolene is $C_{20}\ H_{32}$, and for asphaltene $C_{20}\ H_{30}\ O_{21}$, that is, the petrolene has become oxidized. Thomson deduces the following formulas: petrolene, $C_{10}\ H_8$; asphaltene, $C_{20}\ H_{16}\ O_8$. These two substances, it should be said, have not been clearly determined by chemists, whose results vary greatly.

The opinions of Dr. H. Endemann would seem to overturn the generally accepted theories as regards the nature of asphaltene and petrolene. He adopts a different method of analysis and arrives at very different results. In speaking of the present method in use in America, he says:

> I had to admit and do admit that the analysis as carried out by the later methods suffices to make identity or non-identity of two samples probable or highly probable. It is also adapted to watch the supply of a single mine or the refining of asphalt from the same source; but it does not admit of basing any conclusions upon the results, if we work on asphalts from different sources.

This controversy must be left for American chemists to settle, for when doctors disagree the layman should remain quiet and await results. It is not proposed in this paper to discuss asphalt in all its forms, but only in those that are used for pavements. The engineer must leave the patient investigation of these materials to chemists and accept their conclusions.

The principal places where asphalt is found are the Pitch Lake on the island of Trinidad; Bermudez, Venezuela; Seyssel, France; Travers, Switzerland; Ragusa, Sicily; and in California and Utah, U. S. Some deposits have also been found in Mexico, Kentucky, Texas, Montana, Colorado and Indian Territory.

*Slightly abbreviated from a paper read before the American Society of Civil Engineers, May 5, 1897.

†45 Municipal Building, Brooklyn, New York.

Trinidad Asphalt.—At the time of the author's visit to Trinidad the asphalt was being dug from the lake and carted to the shore with mules. It was then loaded into lighters and taken to the ships anchored in the offing. Since then, however, the concessionaires have constructed a railroad from the shore to and around the lake, so that the pitch can be loaded upon the cars, drawn to the shore, out on an iron pier, and then dumped direct into the hold of the waiting ship, thus greatly reducing the expense of loading.

The material is easily dug up by negro laborers with ordinary pickaxes in chunks averaging about ½ cu. ft. each, the excavations being made of perhaps 5 or 6 ft., or of any convenient depth.

These excavations will fill up from the pressure below in about 48 hours. The surface of the lake has been compared to one formed by placing together a number of large mushrooms, the water previously spoken of standing in the depressions where the mushrooms come together. It has been thought by geologists that this appearance was caused by the material being forced up in a liquid form through a large number of orifices. These different streams, coming together at the top, form a surface, which, when hardened, presents the appearance described.

The asphalt is brought to this country generally in its crude state, and is refined at various points where most convenient for distribution. This refining process consists of heating the material in large iron retorts to a temperature of about 400° for five or six days. This serves to evaporate all the water, and drives off all the volatile oils. The solid foreign matter is allowed to settle to the bottom, and the remainder is drawn off into barrels for shipment. The sediment is then taken out, and is used for sidewalks or similar purposes. Three tons of the crude material makes about two tons of the refined.

Another process of refining or drying asphalt has been used more recently. The apparatus consists of an iron tank large enough to contain about 30 tons of the material. In this tank is a continuous pipe arranged in gangs, something similar to a steam radiator, having a steam pipe to take the condensed water back to the boiler. Another set of pipes, called the live-steam pipes, has a direct boiler connection and a number of jets inserted in it at the bottom, so that the material in the tank can be kept in constant agitation by the injection of hot steam through these jets, thus ensuring a complete and even mixture, as well as more rapid evaporation. After the tank is filled with asphalt, steam is applied at a pressure sufficient to produce a heat of about 300°. The application of this heat for 15 or 16 hours is sufficient in most cases to evaporate all the water from the asphalt, when it is drawn off into barrels for shipment. If the material is to be used near the refining plant, the flux is added before the product is drawn off and the asphaltic cement made on the spot. This method is generally called the drying process, and is economical, both in time and material, as it only requires 16 hours against 90 by the old, and there is no wastage of material. It is held that as so large an amount of extraneous matter must be added to make the pavement, it is a waste of material to lose the amount of sediment which is very similar to what is afterwards added, and under the old plan was often a total loss. This system has been in operation about two years.

An analysis of the refined lake product gave the following result: bitumen, 55.6%; foreign matter, 44.4%; petrolene, 70.12%; asphaltene, 29.78%; specific gravity, 1.38.

California Asphalt.—California produces nearly all the United States asphalt used for paving purposes. While it can be found in this state in nearly all its stages of development, but three of these are adapted to pavements, namely, the maltha, hard asphalt and bituminous rock.

Maltha is a liquid asphalt used principally as a flux for the harder material. It contains a large percentage of bitumen, of which nearly all is petrolene; this determines its value as a flux. On account of the inconvenience of shipping it in its natural condition, the asphaltic cement is made near the mines, which are in Santa Barbara Co., near the city of the same name. The sand and vast beds of underlying shale in this vicinity are saturated with the material, but at present the maltha is obtained from the sand. An upper surface of about 1 ft. of soil is washed off into the ocean and the bed of sand left full and clean. This sand is then gathered up and the maltha extracted by a patent mechanical process. This bed probably extends for several miles under the sea, as the water for a long distance up and down the coast is covered with an oily film showing that this same material must be forced up from the bottom of the ocean. The composition of this material when ready for use is 98.2% bitumen and 1.74% mineral matter; the petrolene amounts to 92.5%. The specific gravity is 1.05.

Some 25 miles east of this deposit is located the principal deposit of the hard asphalt, which extends over an area of several hundred acres. This material is quite hard, presenting an appearance somewhat similar to refined

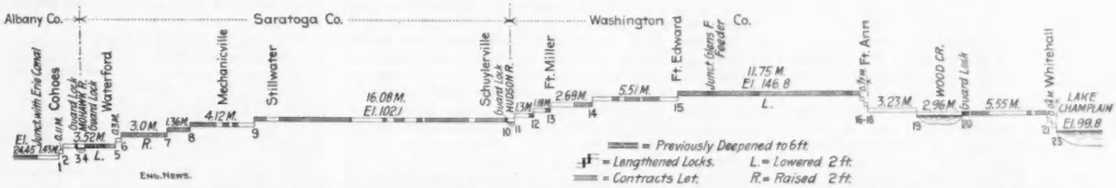

FIG. 3.—PROFILE OF CHAMPLAIN CANAL FROM ITS JUNCTION WITH THE ERIE CANAL TO WHITEHALL, N. Y., 65 MILES.

Another deposit of hard asphalt has been found in Kern County of probably the same origin, but containing a larger percentage of bitumen. It is treated, both in refining and fluxing, in the same manner as that from the Santa Barbara mines. The refined product contains: bitumen, 93.27%; mineral matter, 5.77%; organic matter, 0.54%; moisture, 0.42%; petrolene, 71.27%; asphaltene, 28.73%.

In Santa Cruz, San Luis Obispo and Monterey counties are found deposits of asphalt of an entirely different nature, and pavements laid with its product must not be confounded with the others. It consists of sand thoroughly mixed with an asphalt of such a nature as to make a good pavement in a natural state. The sand is of all grades of fineness, sometimes largely mixed with clay, and often so hard as to be almost a sandstone. Pavements of this material have been quite extensively laid in California cities, the method being simply to heat the crude product so that it can be rolled to a hard smooth surface on the street, in some cases without any prepared foundation. It is not strange that the result of such operations should often prove failures, as no special care seems to have been taken to select the best of the material at hand. These failures have sometimes been charged improperly to the other California asphalts.

Bermudez Asphalt.—The deposit of Bermudez asphalt is situated in the state of the same name in Venezuela. It is across the Gulf of Paria from the Island of Trinidad, and some people think the two deposits are connected subterraneously. The lake is about 5 miles from the shipping point, which itself is 25 miles up a river from the Gulf. It includes an area of some 1,200 or 1,500 acres, covered generally with quite a heavy growth of grass and bushes. Through the lake runs a so-called stream of liquid asphalt, varying in width from 100 to 400 ft. With the exception of this stream, a person can easily walk over the entire surface of the lake, but upon the stream

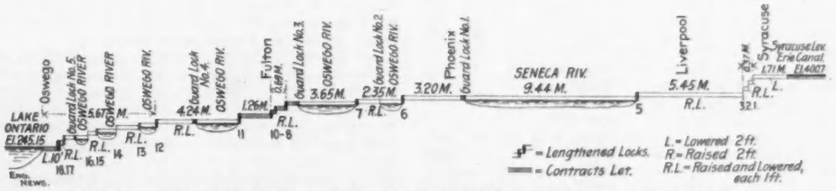

FIG. 4.—PROFILE OF OSWEGO CANAL FROM ITS JUNCTION WITH THE ERIE CANAL TO OSWEGO, N. Y., 38.3 MILES.

itself it is not safe to venture after the sun is two or three hours high. A portable railroad is built out into the lake, upon which light hand-cars are run. After being loaded, the cars are pushed to the shore, where they are unloaded into other cars, and the material then hauled to the shipping point over a permanent steam railroad. These cars are provided with boxes containing about a ton of the crude material, and when delivered alongside the vessel at the wharf the boxes are hoisted from the cars and lowered into the hold of the vessel and there dumped.

The first pavement of Bermudez asphalt was laid in Detroit in 1892. When refined, the asphalt is composed of: bitumen, 97.22%; mineral matter, 1.50%; organic matter, 1.28%; petrolene, 77.90%; asphaltene, 22.10; specific gravity, 1.08.

Utah Asphalt.—The deposits in Utah are situated in Utah Co. They consist of a vein of limestone about 8 ft. in thickness, but only one-fourth of this contains sufficient bitumen to make it profitable for use, the amount being about 30%. In eastern Utah is another deposit called gum asphalt, which is claimed to be pure bitumen. An analysis shows: carbon, 81%; hydrogen, 10%; nitrogen, 3%; and oxygen, 6%.

In preparing a mixture for street work the gum asphalt is melted and fluxed with a small amount of residuum. It is then mixed in the proper proportions with hot sand and the bituminous limestone. This mixing is done in cylinders surrounded with steam jackets, in which steam at a temperature of 600° is kept during the mixing, which continues a few minutes, when the mass is dumped into carts and taken to the street. Pavements of this material have been laid in Salt Lake City, Minneapolis and Marion, O.

Kentucky Asphalt.—The Kentucky deposits are found in sandstone, and should be classed as the rock asphalts. The output is not large, and very little information could be obtained concerning it. Some years ago two pieces of pavement were laid with this material in Brooklyn, and while some of it is in existence now, so little care was taken as to time and manner of laying or name of the contractor that the experiment has been of little value.

Indian Territory Asphalt.—The asphalt deposits of Indian Territory are located in the southwestern part of the territory in the Arbuckle Mts., near the Washita River. They extend over an area of several square miles. The asphalt is found in sand and also bituminous rock. The former contains 16%% and the latter 21% of bitumen. The sand asphalt is used in its natural state in pavements. It is heated in a special apparatus and laid in much the same way as the European rock asphalts, but to the rock asphalt 50% of sand asphalt is added before heating, when it is laid as before. Nearly all the work in the development of this deposit has been done during the past 18 months, the charter for the company from which the present operators leased it having been granted in 1895; consequently very little pavement has been laid with this material, that little being principally the repairs of other pavements. Where used, it has so far given good satisfaction, though from its amount of bitumen it might be expected to make a pavement that would be too soft.

By a process of refining, a bitumen of about the consistency of maltha is produced from the sand asphalt. It is first separated from the sand by being boiled in water. The asphalt, having a smaller specific gravity than water, rises to the surface, when it is still skimmed off and still ther refined as required.

European asphalt.—European asphalts, although somewhat scattered, are found under about the same conditions. They exist in strata of varying depths, from 6 to 23 ft. in thickness, separated from each other by impermeable beds of limestone.

It is supposed that at an early period bitumen must have been vaporized by extreme heat, that the hydrocarbon while in a state of vapor was forced through this limestone while soft, much as subterranean water follows layers of gravel confined by beds of clay or stone, and that fissures in the overlaying rock have permitted the vapor to pass to the other soft strata above. The rock absorbed this vapor to a greater or less extent, and the geological changes occurring in the succeeding years produced the rock asphalt as it is found to-day. To make a good pavement this rock should contain from 9.5% to 10% of bitumen, according to conditions. If one deposit contains too much, it can be mixed with another compound containing less. According to the solvents used, the products of the same mine will produce different results, and that may account for the results given here from three different sources. The bitumen and carbonate of lime form so very large a percentage of the whole that the other ingredients are not considered.

Ragusa.		Seyssel.		Val de Travers.	
Bit.	Carb. of lime.	Bit.	Carb. of lime.	Bit.	Carb. of lime.
9.72	88.75	8.15	91.70	12.00	....
8.92	88.21	9.10	90.35	7.20	....
....	....	7.00	....	10.25	88.40

Pavements.—In 1854 a pavement of rock asphalt was laid on the Rue Bergere, Paris, as an experiment, with such success that four years later another trial was made on Rue St. Honore, from which time may date the beginning of asphalt pavements. In London the first pavement similar to this was laid in 1869, and in Berlin in 1873.

Asphalt as generally laid in this country is simply a bituminous concrete, the sand acting as the body of the mixture, the asphalt simply cementing the particles of sand together.

The success of the European pavements led investigators of this country to make experiments in their own behalf, and from 1870 to 1873 quite a large area of pavement was laid with coal-tar instead of asphalt as a binding material. These pavements failed, as the coal-tar was apt to crack in the winter and be soft and sticky in the summer; or, in other words, a pavement made of coal-tar that would not be soft in hot weather would crack and crumble when the weather became cold. Chemically, there is not much difference between coal-tar and asphalt; in fact, the author was once told by an eminent chemist that he knew of no chemical test by which the presence of coal-tar could be detected in asphalt. If, however, it exists in any amount it can readily be discovered by its odor.

The failure of these pavements led to further investigation on the part of interested people, and in 1870 a bituminous pavement* was laid in Newark, N. J., around the City Hall, followed in 1871 by one in New York, near the Battery, with Trinidad asphalt as the cementing material. About the same time a similar pavement was laid in Philadelphia, and a few years later others in New York. These experiments were so successful that they attracted the attention of the authorities of Washington, and in 1876 a commission appointed under the authority of Congress reported in favor of paving Pennsylvania Avenue with asphalt, using the European bituminous rock on one portion and Trinidad asphalt for the remainder. From the completion of that work dates the complete success of asphalt pavement in the United States, and although a great amount of careful study and further investigation was necessary, the industry has been continually on the increase since that time.

Some eight or nine years ago, in making his annual report to the city council of Omaha, the author had occasion to say that stone and asphalt were the only real paving materials. The experience of the years since then has only made stronger that belief. For a street subjected to heavy traffic there can be no question that granite pavement laid makes the best and most economical pavement, but for a moderate traffic, on reasonable grades, asphalt will give the most general satisfaction. It is smooth, almost noiseless, and can be kept clean. As a sanitary pavement, it is without a rival. It is said to be expensive, and it is to a certain degree, but very few who use it will question the value received. The question of cost and durability will be discussed more in detail later. Some asphalt pavements have failed, but that is not surprising when it is considered how new the industry is, how rapidly it developed, and that all facts about its construction had to be established by pavements actually in use.

The question of how steep a grade it is safe to lay asphalt on has received a great deal of study. Originally grades of even 4% were considered prohibitory, but as more work was done, this was seen to be too conservative a view. Asphalt is now in use upon grades in different cities, as follows: New York city, 6%; Omaha, Neb., 7% to 8%; Brooklyn, N. Y., 4½%; Syracuse, N. Y., 7%.

The objection to steep grades is, of course, the liability of horses to slip down. Contrary to the general belief, asphalt itself is not slippery. It is smooth, and any soft substance upon a smooth surface makes it slippery, but on steep grades foreign matter is less liable to collect than on light ones. The remedy, then, is to keep the pavement clean. It is a fact known by all teamsters that it is harder for a horse to travel on a smooth pavement when it first begins to rain than after a heavy shower when the surface has been washed clean. In view of the experience of the past few years and the fact that all pavements are kept much cleaner than in former times, the conclusion is reached that grades of less than one need not be questioned when considering the advisability of laying a smooth pavement, and in extreme cases those as high as 6% are permissible.

The question of crown or convexity is pertinent here. Streets are paved for use, not for looks, and the cross-section that accommodates travel the best and will carry all water falling upon it to the gutters is the one that should be adopted. Some engineers have a formula for this, based upon the grade of the street and width of roadway. Theoretically this is correct, but in practice it is better to establish a minimum crown and vary from it only when it is absolutely necessary to prevent water from standing on the surface. For a roadway 30 or 34 ft. in width, the following cross-section will give satisfaction at minimum grades. Depth of gutter 5 ins.; centre of street 1 in. below level of curbs, the cross-section of the street being an arc of a circle. This gives the center half of the roadway with a fall to the sides of 1 in. in 7½ or 8½ ft., as the case may be. This is practically level as far as travel is concerned, and for drainage purposes is about 1%, which is ample. On an asphalt street with level curbs the gutters need never be more than 6 ins. deep unless the width be extreme, and the crown of the pavement preferably not higher than the curbs, so that for widths of 50 or 60 ft. between curbs, the crown should not be more than 6 ins.

It often happens that in repaving old streets, one curb is found at a considerably higher elevation than the other. The practice then is to make the gutter on the high side of maximum depth, and that on the lower side of minimum, thereby reducing the difference in the roadway as much as possible. If the elevation of the pavement at the quarter instead of the center be made the highest part of the roadway, the most acceptable cross-section is obtained. Some engineers in such cases advocate laying the pavement with a plane surface from gutter to gutter. By this method the side slope is minimized, but the water is all thrown into one gutter, and it is almost impossible to have work carried out so perfectly that settlements will not show in pavements so laid, holding water after every rain.

Character of Asphalt.—To make a first-class pavement the asphalt should be a good material, properly mixed and well laid upon a good foundation. Whether an asphalt will or will not make a good pavement can only be told by trying. A chemist can analyze an asphalt, tell what are its component parts, and give his idea as to what it ought to do, but the author doubts if any one would be willing to give a definite opinion as to its action in a pavement simply from a laboratory analysis. Stevenson Towle, M. Am. Soc. C. E., in speaking of the partial failure of the Eighth Avenue pavement in New York city, said:*

> This asphalt was submitted to and approved by experts and chemists before the contract was entered into. Soon after the pavement was laid and before its completion (it has never been accepted), it showed unmistakable evidences of disintegration. This failure was exceptional and the experts and chemists who had approved of the asphalt could not account for it. My own belief was that the asphalt was inferior or lacking in some essential property unknown to chemists.

Personally the author would hesitate before giving a final judgment on a pavement that had not passed through at least two winters. An analysis of the refined asphalt is required to ascertain the quantity and quality of the bitumen contained. Then, by former experience with other similar asphalts, and many experiments, the quantity of flux is determined, taking into consideration the climate and amount of traffic.

In this connection, Trinidad asphalt is generally taken as a standard, not because it is the best, but because it is known it will make a good pavement. Any refined asphalt that contains from at least 50% or 60% of bitumen which is composed of approximately 75% petrolene and 25% asphaltene, is deserving of careful invesigation and experiment.

Foundation.—The foundation is the important part of an asphalt pavement. The surface coat is only the carpet; the base must be the floor that sustains the load. No matter how good the top may be, a failure in the base means immediate failure in the pavement. Probably the best foundation and the one most generally in use is made of hydraulic cement concrete. Its thickness varies with the traffic, but should never be less than 6 ins. Some seven or eight years ago, the asphalt companies, wishing to reduce the cost of their pavements wherever practicable, experimented with a broken stone base. This stone was of the ordinary size for concrete, and, after being spread upon the prepared roadbed, was thoroughly compacted with a steam roller. Upon the broken stone was then sprinkled hot coal-tar, in quantity about one gallon per yard, followed by the binder course. This considerably reduced the cost of the work, but as the solidity of the pavement depended directly upon the ground beneath, its use was soon discontinued. In repaving strets, however, it is often well and desirable to retain the old material as a base. This has been very generally done, and with good results, on granite or other stone streets. A few cases where asphalt was laid over old Nicholson pavements resulted disastrously, as might have been expected. One objection to using the old stone base is that the cross-section of the street often needs to be remodeled, involving the relaying of a large amount of the stone. This requires great care to avoid future settlements. On cobble strets chuck holes and other irregularities often exist, too large to be filled economically with binder. In such cases the street can be brought to the proper cross-section with broken stone thoroughly rolled, the old cobble still being the real foundation.

Asphaltic Cement.—The first step in the actual mixing is the preparation of the asphaltic cement. A portion of refined asphalt is carefully weighed and deposited in an iron tank and melted. After it has attained a temperature of about 300°, the flux is added. If this be petroleum residum, it is added in a proportion of from 16 to 20 lbs. for each 100 lbs. of asphalt, according to the consistency desired. The temperature is then maintained for about ten hours, the whole mass being kept constantly in agitation by means of an air blast to ensure a thorough mixing. The quantity of the oil will vary a little according to its quality, as well as that of the asphalt itself.

An ingenious machine has been invented for testing mechanically the asphaltic cement. This apparatus consists of an arm some 17 ins. long, supported at one end

*There is some doubt as to the composition of the Newark pavement. The records do not say whether it was asphalt or a coal-tar mixture.

*See his Report to the Commissioner of Public Works of New York city, January 5th, 1895.

and provided at the other end with a cambric needle above which is placed a weight of 100 grams. The needle end is connected by a rod and cord with a large hand that moves around a dial divided into 360°. By a spring attachment the needle is brought into contact with the asphaltic cement for any desired time, and the amount of penetration marked in degrees on the dial.

For comparative tests it is, of course, important that all samples be used at the same temperature. This can most easily be accomplished by placing the cement in water when ready for the test and keping it at the required temperature, generally from 75 to 80° Fahr. The author knows of no place where this machine is extensively used except in Washington. The report of the Engineer Commissioner for the year ending June 30, 1895, gives the average penetration of the product of three companies at70° F. as 69, 73 and 85. In the following year the average of the cement furnished by one of the above companies was 75.

The residum oil should have a specific gravity of about 20° Beaume, a flash point of 300° F., and should distil not more than 9% or 10% in ten hours at a temperature of 400° F.

If maltha or some other flux be used, it should be treated practically as above, modified according to the properties of the particular material.

Wearing Surface.—Asphalt pavement was first laid in two layers, a cushion coat of ½ in., and a wearing surface 2 ins. in thickness. After some experience it was seen that the upper surface sometimes slipped on the lower, or the whole slipped on the concrete, thus forming a wavy and uneven surface. To counteract this, there was laid instead of the cushion coat, the so-called binder. This consisted of clean broken stone, cemented together with coal-tar, but later, on account of the variableness of the tar, asphaltic cement was substituted as a cementing material. The thickness of this binder is 1 or 1½ ins. As its object is simply to connect the wearing surface with the concrete, there appears to be no good reason for making it more than 1 in. Where binder is used, the wearing surface is 1½ or 2 ins. thick, according to the traffic, the general practice being where the binder is 1 in. to make the wearing surface 2 ins., so as to have the pavement in no case less than 3 ins. thick.

The stone for the binder should be thoroughly clean, and vary in size from ½-in. in its smallest to 1 in. in its largest dimensions. It should be heated to a temperature of about 300° F., the asphaltic cement added in the proportion of about 20 galls. of cement to a cubic yard of stone and the whole mass mixed till each piece of stone is completely coated. It is then carted to the street and spread upon the concrete so as to give the required depth when rolled. It is neither intended nor desired to fill all the voids in the stone, and care must be exercised to use no more cement than is necessary to bind the stone together. Should there be an excess, it will rise in warm weather and soften the wearing surface, and cause a failure. Such a case as this came under the author's observation, and an analysis of the asphalt showed an excess of 50% of bitumen. The mixture for the wearing surface consists of sand, asphaltic cement and pulverized limestone. The exact proportions vary according to conditions, but in the vicinity of New York are approximately: sand, 710 lbs.; asphaltic cement, 110 lbs.; pulverized limestone, 60 lbs. These proportions will vary according to the character of the sand and amount of bitumen in the asphaltic cement, but they should produce from 9% to 11.5% of bitumen in the finished pavement.

In this mixture it is very necessary that all voids should be filled, and the amount of stone dust depends upon the coarseness of the sand. The use of the limestone dust as a filler has a tendency to make the surface hard and slippery. At first it was thought that the carbonate of lime had a chemical effect on the bitumen, but that idea is about given up, and the author believes that if there were used in its place an impalpable powder made of the silicious gravel found on Long Island, the pavements would be improved.

The sand is heated in a special apparatus to a temperature of about 400° F. and elevated to the mixing platform. It is necessary that this temperature should be uniform, as an extreme heat in even a few hundred pounds might burn and destroy quite a quantity of asphaltic cement, and defects would soon develop in the pavement. While the wearing surface is being laid upon the streets, several tanks are kept full of the cement at a temperature of about 300° F. The proportions having been determined, the sand, asphaltic cement and stone dust are thoroughly mixed in a pug mill for 1½ minutes, when the mixture is dumped into carts below. It should be delivered on the street at a temperature of from 250° to 275° F., and experience has shown that when covered with canvas it will not lose more than 10° or 15° of heat for ordinary distances and temperatures. After being dumped on the binder, it is raked smooth and even, so as to give the required thickness after having received a compression of 40%. This depth can be regulated by a good foreman with experienced rakers. The first compression should be applied with iron rollers worked by hand. Hydraulic cement is then lightly scattered over the surface, when it should be rolled with a steam roller of 4 or 5 tons, followed in a short time by a third, weighing from 250 to 300 lbs. per inch of width. The object of the different rollers is to apply the weight gradually so as to have the whole compression vertical, rather than with a push, which might occur if too heavy a weight were applied before the material had received a partial compression, thus giving a wavy surface. The rolling should continue as long as any compression takes place, and approximately about five hours for each 1,000 yds. of completed pavement.

Too much attention cannot be given to the rolling, for upon this depends the success of the whole work. Unless thoroughly compressed, the material will have very little cohesive strength. The necessity of this was once impressed upon the author when a street was paved late in the season; and soon after its completion, the mercury fell considerably below the freezing point. This street was one of some thirty contracts that had been completed by the same contractor with the same material, all of which had given perfect satisfaction. In a few days the surface of the pavement began to pick up under travel and the contractor voluntarily relaid a portion of it. For a time it looked as if the entire block must be taken up, but the weather suddenly grew warmer, softening the material so that it would compress under travel, and in a few days the street was perfectly smooth and has remained so ever since. Had the weather remained mild for a few weeks after the work was completed, no trouble would have ensued. The rolling should be begun as soon as the material is leveled off, and continued to completion. Whenever the width of the street will allow it, the rollers should be worked across the street, and on lesser widths diagonally from side to side so as to remove any slight irregularities of surface that might be produced by a continuous rolling in one direction. It is always difficult to get perfect compression along the curb. Consequently it is customary to paint the gutter for a width of about 1 ft. with asphaltic cement, so as to fill completely any pores that might be left open by lack of compression. This cement should be applied before the pavement has become cool, and well ironed with irons specially made and heated for the purpose.

Rock Asphalt.—Rock asphalt is taken from the mines and shipped to this country in its natural state. After being mixed in the proportions determined upon, it is first crushed with rollers and then reduced to a fine powder by being passed through disintegrators, after which it is sifted through sieves to separate any lumps that might otherwise get into the pavement. This powder is then heated in a cylinder, which is kept constantly in motion to allow the air to circulate freely among the particles, and kept for about two hours at a temperature of 300° or 325° F. The material is then carried in carts to the street and spread upon the prepared base to a depth that will give the required thickness when thoroughly compacted. A light roller is then run over the surface to give the initial compression, when workmen, each with a round iron rammer 6 or 7 ins. in diameter, carefully go over the portion of the street covered, all striking blows in unison on the asphalt until it is well compacted. A thin coating of hydraulic cement is spread over the surface when it is ready for the final rolling, which is done by steam and preferably with an arrangement inside the roller for keeping it hot. About twelve hours after the rolling is completed and the material has become cold, the street can be thrown open to travel, which continually adds to the compression already given.

Asphalt Block.—A form of asphalt pavement different from those just described is that composed of asphalt blocks. Pavement of this kind was first laid in San Francisco in 1869. The results were not good, but the promoters were sufficiently encouraged to continue the experiment with improved appliances until its success was assured. The blocks are generally $4 \times 5 \times 12$ ins., but are sometimes made but 4 ins. deep where the travel is light or the foundation particularly good. They are made by mixing broken stone with asphaltic cement and subjecting the whole to a heavy pressure. Limestone has been used; trap rock is preferable, where it can be obtained, as it stands the action of the weather and traffic much better. The stone is crushed to a proper size, and after being screened is heated to a temperature of from 300° to 350° F., when the asphaltic cement and a little pulverized limestone are added and the whole thoroughly mixed. The mixture is then placed in molds and a pressure of 3,000 lbs. per sq. in. applied until the mass is thoroughly compacted, when it is at once cooled under water and is ready for use. The proportions generally used are 73% broken stone, 13% asphaltic cement, and 10% pulverized limestone, the amount of the last varying with the size of the stone. It is claimed by the advocates of this pavement that the blocks, being made separately, each one receiving a regular and uniform pressure, will give better results on the street than sheet asphalt. They also claim that, on account of the size of the blocks, a concrete base is not necessary, but one made of broken stone or gravel thoroughly compacted with a steam roller is sufficient, or if concrete be used the depth of the concrete can be reduced. When the foundation is prepared, the blocks are laid upon it practically as stone blocks are, care being taken to make close and straight joints across the street. This form of pavement has been laid in many Eastern cities, but in and around New York does not seem to compete successfully with sheet asphalt.

Cost and Maintenance.—When it is considered under what conditions and for what length of time asphalt pavements have been laid, it is not strange that reliable data as to first cost, as well as to repairs, are not at hand. Asphalt has almost always been laid with a guaranty to keep it in good repair for a period varying from 5 to 15 years. The price bid has, of course, included the cost of maintenance for the guaranteed time. Throughout the West, when this pavement was first laid, it cost for years $2.95 per sq. yd. on 6 ins. of concrete. The introduction of new asphalts, together with competition, has somewhat reduced this price, so that contracts have been made in Omaha for asphalt pavement on a 4½-in. concrete base for $2.07 per sq. yd., with a five-year guaranty, and in St. Paul for $2.53, and in Minneapolis for $2.43 per sq. yd., both of these being on 6 ins. of concrete, with a ten-year guaranty. Brooklyn has let several contracts for $1.55 per sq. yd. on a 6-in. concrete base, with a five-year guaranty, while the Fifth Ave. pavement in New York will cost $4.60, with a guaranty period for 15 years. Taking all conditions into consideration, these two last prices are probably as low as any received in this country.

Different cities have different methods of making their repairs. When the guaranty periods began to expire in Omaha in 1888 and 1889, the Barber Asphalt Paving Co. entered into contract with the city to keep all their pavements in good condition for a further period of ten years for 8 cts. per yd. per year, making the entire cost for fifteen years $3.75. Since then, however, contracts have been entered into for a specified price per yard of material actually laid.

In Buffalo the other method is adopted, the contractor agreeing to keep each patch in repair for a term of years. This necessitates the exact location of each patch as it is made, and in a few years the patches overlap each other, involving a large amount of work in keeping up the record.

In Washington it has been the practice to pay a specified price per cubic yard for all material used. This plan requires inspectors thoroughly conversant with their business, so that defects in material or workmanship can be readily detected.

In Buffalo, where the cost of repairs has been kept with a great deal of care, the expense has been as follows:

Years maintained.	Cost per yard per year, cts.	Years maintained.	Cost per yard per year, cts.
1	1.70	7	7.18
2	3.05	8	2.89
3	3.89	9	1.22
4	9.17	10	2.59
5	6.78	11	3.35
6	4.63		

The average for the above is 5.5 cts. per sq. yd. per year.

In Washington the resurfacing and repairs from 1879 to 1895 cost 7.7 cts. per yd. per year. During this time 676,390 sq. yds. were entirely relaid, at an average cost of $1.51 per yd. Deducting this cost from the above, the expense of actual repairs was 2.3 cts. per yd. per year. During the last two years a device has been used which has considerably decreased the actual cost of repairing asphalt. This consists of an apparatus by which a concentrated gasoline flame is thrown upon the pavement, heating it to such a degree that all the dead and inert material can be easily scraped off and the surface roughened with toothed hoes, so that the new material can be laid and compressed to give a good bond with that already on the street. By means of this machine, repairs can be made more rapidly and neatly.

The question of repairs and how they should be made is one of great importance. It seems to the author that the method which will give the best satisfaction is to award a contract to responsible parties to keep a certain number of streets, or all in any city if the yardage be not too great, in repair for a term of five years for a specified price per yard per year, including all streets of which the guaranty expires during the contract period. Provision should be made, of course, to reserve enough money till final payment to ensure the carrying out of the contract. By this plan it would be for the contractor's interest to keep the streets in good condition at all times, as that old proverb, "a stitch in time saves nine," can never be applied with more force than to the repairs of an asphalt pavement.

The life of the pavement varies much with conditions. Some require entire resurfacing inside of the first five years, others are reported to have lasted 10 or 12 years with merely nominal repairs. In the light of present experience it would seem that asphalt on a street of ordinary traffic under normal conditions ought to last from 12 to 15 years before requiring relaying, and should not cost more than 6 cts. per yd. per year for maintenance after a five-year guaranty period.

This industry, which was just being thought of in 1870, and was still in its infancy in 1880, has now assumed vast proportions. On Jan. 1, 1897, there was laid in this country, as nearly as could be ascertained, 27,468,915 sq. yds. of asphalt pavement, divided as follows; Trinidad asphalt, 21,527,415 sq. yds.; Bermudez asphalt, 697,500 sq. yds.; Alcatraz (California) asphalt, 916,000 sq. yds.; Standard (California) asphalt, 200,000 sq. yds.; foreign rock asphalt,

603,000 sq. yds.; Utah rock asphalt, 293,000 sq. yds.; other asphalt in the Pacific Coast States (estimated), 1,032,000 sq. yds.; asphalt block, 2,200,000 sq. yds.

Of this amount Buffalo contains more than any other American city, having at the present time 3,663,402 sq. yds. Washington, D. C., comes next with 2,554,262 sq. yds. on June 30, 1896; this amount includes 477,416 sq. yds. of coal-tar and concrete pavement not considered in the above grand total, but excludes 170,229 sq. yds. laid in the suburbs.

Asphalt in Europe.—The principal cities in Europe having asphalt pavements are London, Paris, Berlin and Vienna. These are all laid with the rock asphalts heretofore spoken of, being called in France asphalte comprime, and in Germany Stampf-Asphaltum.

The amounts in these cities are as follows: London proper, 208,000 sq. yds.; Paris, 403,000 sq. yds.; Berlin, 1,600,000 sq. yds.; Vienna, 93,000 sq. yds.

The original cost per square yard on a concrete base 6 to 8 ins. thick was $3.25 in London, $3.60 in Paris, $2.77 in Berlin, and $3 in Vienna.

The cost of repairs per square yard per annum was 6 to 44 cts. in London, 47½ cts. in Paris, and 10 cts. in Berlin, for a period of 15 years after the guaranty expired. On railroad streets 15 cts. for space between tracks and for a distance of 27½ ins. (70 cms.) outside.

In considering the cost of maintenance of European asphalt pavements, the large amount of traffic they sustain must be taken into account. A report of the Chief Engineer of Paris gives this traffic as follows, the figures being the number of vehicles passing in 24 hours:

Paris.

Rue de Rivoli.....	42,035	Rue Auber	14,082
Rue Croix des Petits Champs	20,480	Avenue de la Grande Armee....	8,149
Rue St. Honore	19,672		

London.

King William St....	26,703	Holborn Viaduct ...	12,158
Gracechurch St.. ..	15,585	Newgate St..	13,128
Queen Victoria St...	16,531	Moorgate St	11,398
Cheapside	15,206	Cornhill	9,572
Aldgate	14,200		

SPECIAL POWER PUMPING PLANTS FOR SMALL WATER-WORKS SYSTEMS.

We have spoken several times of the increasing use of small power pumps operated by electric motors and gas engines for small water-works plants, and in our issue of May 28, 1896, a number of installations of this character were illustrated and described at some length. The demand for this class of machinery has induced a number of manufacturers to make special provisions to supply it, and in the accompanying cuts we show two forms of power pumping plants being manufactured by the Stilwell-Bierce & Smith-Vaile Co., of Dayton, O. Fig. 1 shows an 8×8-in. plunger triplex pump connected by a friction clutch to a 10 HP. gas engine, and the second view a similar pump operated by belt from an electric motor.

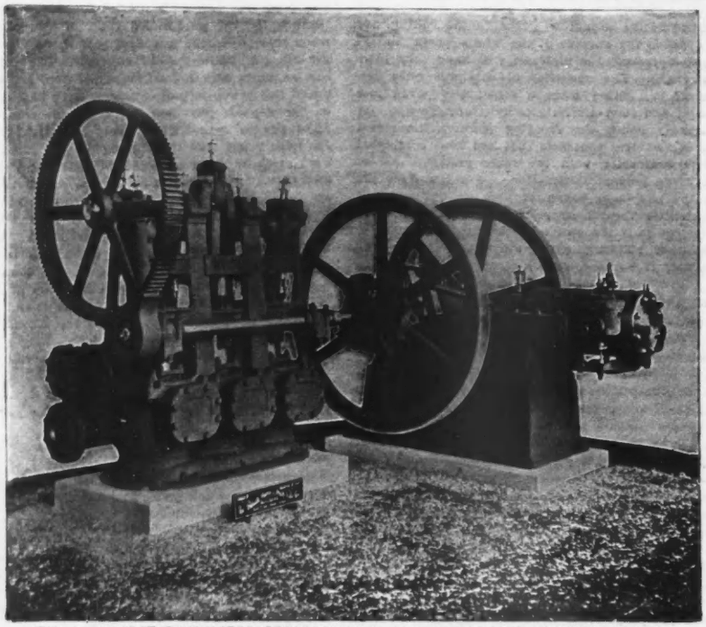

FIG. 1.—DIRECT CONNECTED TRIPLEX PUMP AND GAS ENGINE PUMPING PLANT.
Stilwell-Bierce & Smith-Vaile Co., Dayton, O., Builders.

The firm also supplies a pump geared directly to the electric motor shaft. The following description of the pumps proper has been furnished to us by the manufacturers:

These pumps are built on the principle that a continuous action of the plungers produces a constant flow of water and a resultant high efficiency. They have three plungers connected to a three throw crank-shaft, with the cranks set at an angular advance of 120°. The crank-shaft is supported by four housings and bearings, forming a very rigid construction and perfectly balancing the strains, which in this type of pump are very unequal. The plungers are provided with crossheads and guides; the crossheads have adjustable bronze shoes for taking up wear. The connecting rods have strap heads, brass boxes and taper key adjustments. The pumps are made both single and double acting. The double acting pumps are provided with removable cylinders. The gears are machine cut; the counter-shaft, guides and connecting rod bearings are self-oiling; and the pumps are provided with an extra large valve area, which permits a high speed of piston travel. Ample room has been allowed for getting at the moving parts, to adjust the packing, etc.; the idea throughout being to make this the most perfect machine of its type. The pumps are made in a number of sizes and weights adaptable to all kinds of service.

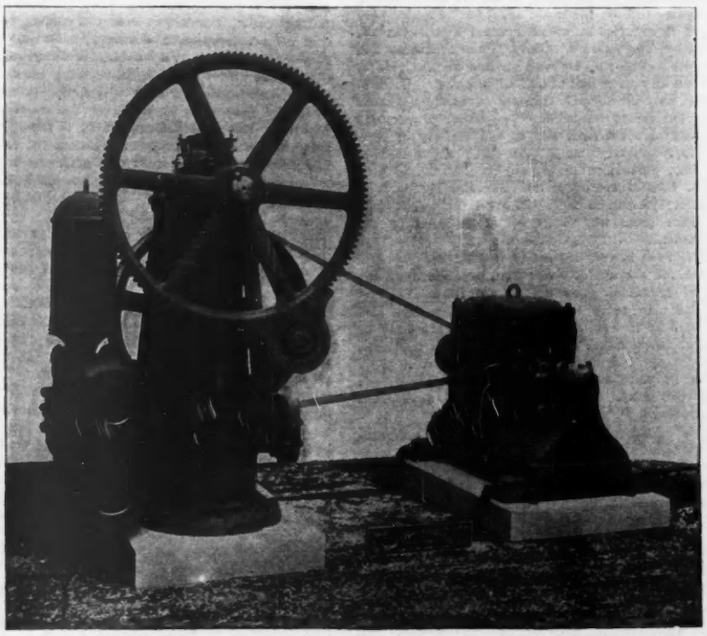

FIG. 2.—BELT CONNECTED TRIPLEX PUMP AND ELECTRIC MOTOR PUMPING PLANT.
Stilwell-Bierce & Smith-Vaile Co., Dayton, O., Builders.

LEGAL DECISIONS OF INTEREST TO ENGINEERS.

Liability of Sewer Builder.

Where a sewer builder, knowing of the dangerous condition of a sewer 13 ft. below the surface, calls an employee from a place of safety and commands him to work in such dangerous place without warning him of the increased hazard, the danger is not a risk assumed by such workman or one voluntarily assumed by him, and the contractor is liable for injury resulting. Banks v. City of Effingham, 63 Ill. App. Ct. Rep., 221.

Recovering Damages for Repair of Pavement.

A company which had a contract with the city to keep a certain pavement in repair consented to an excavation thereunder by another party, on condition that the latter pay for the repairing "upon agreed charges." It repaired the damage and rendered a bill to which the other did not object on the ground that no charges were agreed upon, but contended that part of the expense should be paid by the builder of its building, who was primarily liable. It was held that the suit could not be defeated on the ground that no charges had been agreed upon. Barber Asphalt Paving Co. v. N. Y. Post Graduate Medical Sch., etc. (N. Y. Supreme Ct.), 44 N. Y. Supp. Rep., 457.

Right to Use Future Discoveries.

A statute authorizing a street railway company to use "motive power produced by steam, caloric, compressed air, or by any other means or machinery," will include means undiscovered at the time of its passage and cover the use of electric power. Bell Tel. Co. v. Montreal St. Ry. Co., 10 C. S. Rep., 162.

Conclusion of Engineers Not Binding.

Engineers appointed to determine any question that may arise in regard to the performance of a contract for public work, or in regard to the mode of doing the work while it is going on, cannot bind the town by a construction of the contract not justified by its terms. Braney v. Millbury (Mass.), 44 N. E. Rep., 1060.

THE FRICTION OF BICYCLE CHAINS is being investigated in the engineering laboratories of Sibley College, Cornell University, under the direction of Prof. R. C. Carpenter. The question of chainless gearing has also received some attention. The results of the tests so far made are unfavorable to all forms of wheels driven by other means than the usual chain. Prof. Carpenter says:

Our investigations are not entirely completed at the present time, but it seems safe to announce that all the tests indicate that no form of gearing can possibly equal the best chain for efficiency and durability.

As a result of tests of chains which had been in actual and severe use, it was found that friction varied from 2 to 5%, depending upon the construction and previous use. The highest friction found was 10% in the case of an old chain which did not fit the sprocket. The friction of a complete wheel was tested under working conditions in several instances and found to vary from 5 to 40% of the power applied. For high grade wheels this value ranged between 5 and 8%. In all the tests of bevel gears and geared bicycles the chain gear was found more efficient than the other forms. Another feature adding to the success of the chain in competition with chainless wheels is that the friction remains practically constant at all loads, while with the geared wheel the friction is greatest when the load is greatest.